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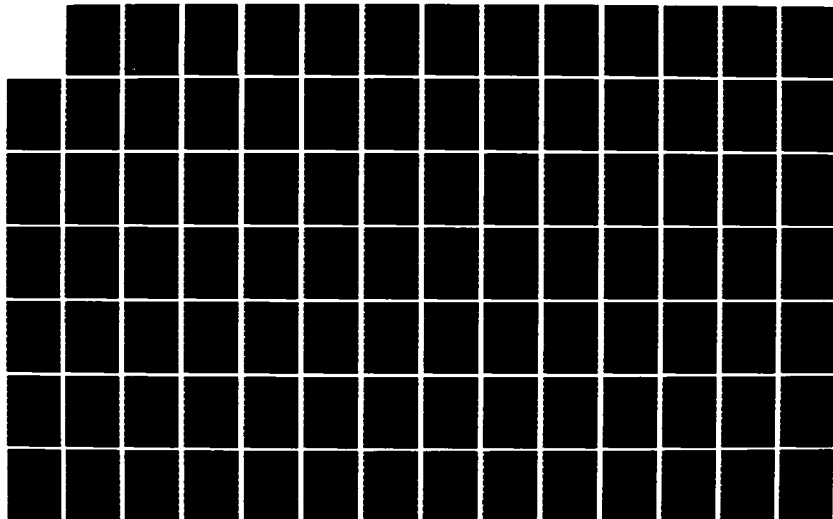
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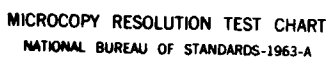
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A SURVEY OF SERIOUS AIRCRAFT ACCIDENTS INVOLVING FATIGUE FRACTURE

VOL. 2 ROTARY-WING AIRCRAFT

by

Glen S. Campbell, R.T.C. Lahey

National Aeronautical Establishment

AERONAUTICAL NOTE

NAE-AN-8

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OTTAWA
APRIL 1983

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FATIGUE FRACTURE
VOL. 2 — ROTARY-WING AIRCRAFT

ÉTUDE SUR DES ACCIDENTS IMPORTANTS D'AVIONS DÙ
AUX EFFETS DES FRACTURES DE FATIGUE
VOLUME 2 — EFFETS SUR DES HÉLICOPTÈRES



by/par

Glen S. Campbell and R.T.C. Lahey

National Aeronautical Establishment

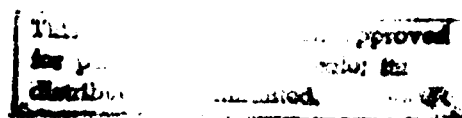
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SUMMARY

This is Volume 2 of a world-wide survey of serious aircraft accidents involving fatigue fracture. Volume 2 of the report deals with rotary-wing aircraft, while Volume 1 addressed fixed-wing aircraft. A total of 419 rotary-wing accidents since 1937 were identified as having fatigue fracture as a related cause, and these accidents resulted in 379 fatalities. The accidents cover civil and, to a limited extent, military aircraft. Accidents are listed by failure type, as well as by aircraft type. Engine/transmission failure and tail-rotor failure were the most common cause of rotary-wing accidents, and currently there is an average of about 31 rotary-wing fatigue accidents per year.

↑

RÉSUMÉ

Ceci est le volume 2 d'une étude mondiale sur les accidents importants d'avions dû aux effets des fractures de fatigue. Il porte sur les hélicoptères tandis que le volume 1 traite des avions. Depuis 1937, il y eu 419 accidents d'hélicoptères résultant de fractures dû aux effets de fatigue. De tous ces accidents, 379 personnes sont décédées. La plupart de ces accidents touchent les hélicoptères civils tandis qu'un nombre limité touche les hélicoptères militaires. Il existe deux listes qui décrivent ces accidents. L'une divise les accidents en différents types de fractures tandis que l'autre divise les accidents suivant les modèles d'hélicoptères. Les deux causes importantes d'accidents sont les fractures au bloc moteur/transmission et les fractures au rotor de queue. Actuellement, il y a environ 31 accidents d'hélicoptères dû à la fatigue par année.

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1.0 INTRODUCTION

This report is Volume 2 of a study of serious aircraft accidents involving fatigue fracture. Volume 1 (Ref. 1) deals with fixed-wing aircraft, while Volume 2 addresses rotary-wing aircraft. The present study is a follow-up to References 2 and 3, which listed fatal aircraft accidents (both fixed-wing and rotary-wing) involving metal fatigue.

That study listed civil and, to a limited extent, military accidents worldwide for the period 1934 to early 1980. The listing was not complete, as it was difficult to obtain information on accidents that happened prior to the early 1960s. The exception was for large civil aircraft, for which complete records go back to about 1945. Nonetheless, the survey was able to document a total of 306 accidents, in which a total of 1803 people were killed. The results also showed that worldwide there was at that time an average of 18 fatal aircraft accidents per year resulting from metal fatigue.

That study excluded a number of significant fatigue failures for which a fatality did not occur, either because of piloting skill or because of good fortune. In the present study, the survey has been expanded to include accidents involving either

- a fatality,
- substantial damage to the airframe, or
- aircraft destroyed.

Accidents are included in the survey if fatigue fracture was somehow involved, although not necessarily as the primary cause of the accident.

The results of the survey are given in two parts:

- Volume 1 - fixed-wing aircraft (Ref. 1),
- Volume 2 - rotary-wing aircraft (this report).

The complete survey covers both fixed-wing aircraft and helicopters, and lists 1885 accidents since 1927, involving 2240 fatalities.

This volume (rotary-wing aircraft) lists 419 accidents, which have resulted in 379 fatalities. The accidents are listed two ways, first by failure type, such as main-rotor or tail-rotor failure, and secondly by aircraft type.

It should be noted that this survey cannot be claimed to be comprehensive, and is restricted to the sources listed in Section 3. The survey does, however, indicate the magnitude of the fatigue problem.

How to Use This Report

In this report, the information is presented a number of different ways:

(1) For a listing of accidents by major component or system, see the following Appendices:

- main-rotor system	Appendix J
- tail-rotor	Appendix K
- airframe	Appendix L
- flight controls	Appendix M
- engine or transmission	Appendix N
- landing gear	Appendix O
- miscellaneous	Appendix P

(Note: The Appendices in this report begin at Appendix J. Appendices A to I are found in Volume 1, and deal with fixed-wing aircraft.)

(2) For a listing of fatigue failures experienced by a particular aircraft type, see Appendix Q ("LIST OF ROTARY-WING ACCIDENTS - ORDERED BY AIRCRAFT TYPE"). A summary of repeated fatigue failures is found in Table 2 ("LIST OF REPEATED FATIGUE FAILURES - ROTARY-WING").

(3) To find out what accidents occurred in a particular country, or belonging to a particular military service, see the cross-reference listing in Table 5 ("LIST OF ACCIDENTS BY COUNTRY - ROTARY-WING") and use the identification number to find the corresponding accident in Appendices J through P.

(4) To find out accidents occurring from a particular form of crack initiation (for example "fretting"), look up the cross-reference list in Table 4, and use the identification number to find the accident in Appendices J through P.

2.0 DEFINITIONS AND ABBREVIATIONS

The definition of "aircraft accident" in this report is the one used by the International Civil Aviation Organization (Ref. 4):

"Aircraft Accident: An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all persons have disembarked, in which:

- (a) any person suffers death or serious injury as a result of being in or upon the aircraft by direct contact with the aircraft or anything attached thereto, or
- (b) the aircraft receives substantial damage.

Substantial Damage: Damage or structural failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft and which would normally require the major repair or replacement of the affected component. The following types of damage are specifically excluded: engine failure, damage limited to an engine, bent fairings or cowlings, dented skin, small punctured holes in the skin or fabric, taxiing damage to propeller blades, damage to tires, engine accessories, brakes, or wing tips."

List of Abbreviations Used

The following abbreviations have been used in this report:

AA	Administration de l'Aeronautique (Belgium).
AD	Airworthiness Directive.
AF	Air Force.
AFFDL	US Air Force Flight Dynamics Laboratory.
AHS	American Helicopter Society.
ARC	UK Aeronautical Research Council.
ARL	Australian Aeronautical Research Laboratories.
ASTM	American Society for Testing and Materials.
AWST	"AVIATION WEEK & SPACE TECHNOLOGY" magazine.
AW	"AVIATION WEEK" magazine.
BoA	Board of Aviation.
BoT	Board of Trade.
CAA	UK Civil Aviation Authority.
CAB	US Civil Aeronautics Board.
CF ACAIRS	Canadian Forces Aircraft Accident Reporting System (a computer storage/retrieval system for accident data).
D	Substantial damage to the airframe.
Dam	Damage to the airframe.
DoT	Department of Transport.
FI	"FLIGHT INTERNATIONAL" magazine.
ICAF	International Committee on Aeronautical Fatigue.
ICAO	International Civil Aviation Organization.
ICAO AAD	ICAO "AIRCRAFT ACCIDENT DIGEST".
ICAO ADREP	ICAO Accident Data Report (a computer storage/retrieval system for accident data).
MLG	Main landing gear.
MoT	Ministry of Transport (Canada).
NBS	US National Bureau of Standards.
NTSB	National Transportation Safety Board (USA).
NTSB AAR	NTSB Aircraft Accident Report.
NZ AAR	New Zealand Aircraft Accident Report.
NZ AIB	New Zealand Accident Investigation Bureau.
RAN	Royal Australian Navy
RAAF	Royal Australian Air Force
RAF	Royal Air Force, UK
S	Substantial damage.
UK	United Kingdom.
USAF	United States Air Force.
WAAS	"WORLD AIRLINE ACCIDENT SUMMARY" (Ref. 5).
WADC	Wright Air Development Centre
WHAS	"WORLD HELICOPTER ACCIDENT SUMMARY" (part 2 of Ref. 5).

3.0 SOURCES OF INFORMATION

The following sources were used for information on fatigue-related accidents:

World-Wide Civil Accidents

1. "WORLD HELICOPTER / ACCIDENT SUMMARY" (part 2 of Ref. 5). This reference, which is updated once a year, lists all civil aircraft accidents that have occurred since 1956. Rotary-wing aircraft over 4550 kg (10,000 lb) maximum gross weight are covered.

2. International Civil Aviation Organization (ICAO). ICAO has a computer data-bank of all civil aircraft accidents for 1970 and onwards. The data-bank covers all civil aircraft, both fixed-wing and helicopter, whose gross weight is over 2250 kg (4960 lb).

3. Magazines, such as "AVIATION WEEK & SPACE TECHNOLOGY", "FLIGHT INTERNATIONAL", and "INTERNATIONAL HELICOPTER".

In addition, all the member countries of ICAO were queried for civil accident information, and National Delegates from the International Committee on Aeronautical Fatigue were asked to obtain whatever information was openly available from the military authorities in their country. The following countries provided information for the periods indicated:

CIVIL	MILITARY
Argentina	Royal Australian Air Force (1953 - 1981)
Australia (1969 - mid-1981)	Royal Australian Navy (1959 - 1981)
Barbados	Belgian Air Force (to mid-1981)
Belgium (1950 - mid-1981)	Canadian Forces (1950 - early 1981)
Brazil	Swedish Air Force (1967 - Aug. 1981)
Burma	UK - Royal Air Force
Canada (1916 - mid-1982)	US Army (1972 - Mar. 1981)
Cape Verde	
Cyprus	
Egypt	
Finland (1962 - Jan. 1982)	
Federal Republic of Germany (1975 - Aug. 1981)	
Greece	
Guyana	
Hong Kong	
Iceland	
Iraq	
Ireland	
Jamaica (1966 - 1981)	
Japan (1973 - Feb. 81)	
Kenya	
Lethoso	
Malaysia	
Malawi	
Malta	
Mexico	
Netherlands	
New Zealand	
Norway	
Pakistan	
Papua New Guinea	
Portugal	
Rwanda	
Seychelles	
South Africa (to April 1981)	
Sweden	
Switzerland	
Thailand	
USA (1964 - late 1981)	

Data on accidents prior to the introduction of the ICAO reporting system in the late 1940s are very difficult to obtain. Details of accidents to aircraft below 2250 kg (4960 lb) gross weight (the lower limit for which accidents are reported to ICAO) are scarce prior to the mid 1960s, when countries began transferring to computer storage and retrieval of accident data.

There are almost no accident data available from communist countries, as they do not divulge accident data, not even to ICAO.

Because of security reasons, only six countries were able to provide data on accidents to military aircraft. The few examples from other countries included in this report were obtained from news reports and trade publications.

4.0 RESULTS

The results of the survey are summarized in Table 1. A total of 419 rotary-wing accidents were found, resulting in 379 fatalities. Including the fixed-wing accidents from Volume 1 of this survey (Ref. 1) gives a combined fixed-wing and rotary-wing total of 1885 accidents and 2240 fatalities. A total of 393 fixed-wing and 165 rotary-wing aircraft were destroyed.

For rotary-wing aircraft, failure of the engine or transmission was the most common fatigue problem, and accounted for 32% of the accidents. Following close behind was tail rotor failures (24% of the rotary-wing accidents), and then the main-rotor system (13%).

4.1 Listing of Accidents

Where possible the following information is given in the listings for each accident:

- Aircraft type
- Aircraft operator (private aircraft excepted)
- Accident date
- Damage to airframe ("D" = destroyed, "S" = substantial)
- Number of fatalities
- Geographical location of the accident
- A brief description of the location of the fatigue failure
- A reference to the accident report number, or where information on the accident was obtained. (To conserve space, references are only given in the listing by failure type).

Each accident has been assigned an identification number for cross-referencing purposes. The identification number consists of a letter, corresponding to the Appendix in which the accident is listed, and a number, referring to the number of the accident within the Appendix. For example, the identification number J39 refers to the 39th accident listed in Appendix J (rotary-wing aircraft, main-rotor system failure).

The listing of fixed-wing accidents according to failure type is

found in Appendices J through P.

The earliest reported accident was the 1937 failure of a main rotor blade of a U.S. Air Force autogyro of unspecified type (item J1 in Appendix J). Fortunately, as the rotor blade was shed, the pilot and observer were both thrown clear and parachuted to safety. The tubular blade spar was attached to a fork at the inboard end of the blade by means of pins, and failure occurred at the outboard pin hole (Ref. 6).

The listing of accidents by aircraft type is given in Appendix Q. Three accidents occurred for which the aircraft type was not specified, and these are listed at the end of Appendix Q under the headings "Type Unknown". The authors welcome any further information on these accidents.

4.2 List of Repeated Failures

Table 2 lists rotary-wing aircraft that have had more than one serious accident resulting from metal fatigue of the same general area. (There is a similar list for fixed-wing aircraft in Reference 1.) Unfortunately, there was generally insufficient information available to determine if these failures were in precisely the same part and location.

The ordering of the list is by number of accidents. For additional information on individual accidents, refer to the corresponding identification numbers in Appendices J through P.

In searching for repeated fatigue failures, it is advised also to check the aircraft type under Appendix Q ("Listing of Accidents by Aircraft Type"), as some accidents have insufficient information to pinpoint the exact failure location, so additional failures may appear in that Appendix that do not show up in Table 2.

Some examples of repeated failures are:

<u>Aircraft</u>	<u>No. of Accidents</u>	<u>Failure Area</u>
Bell 47	42	Tail rotor blade
Bell 47	7	Tail rotor blade yoke
Hughes 269	7	Tailboom
Bell 47	6	Tail rotor retention bolt
Brantly B-2	6	Tail rotor blade

It is beyond the scope of this report to examine each of the cases of repeated failure in order to determine which are still on-going and have not had sufficient action taken in order to arrest the problem. An examination of the Airworthiness Directives for the aircraft in question would be required, as well as a detailed review of the accident reports to determine if the accident was not simply a result of inadequate maintenance by the operator. Examples of recent fatigue failures that have occurred at least three times in the past include:

AIRCRAFT	FAILURE AREA	NO. OF ACCIDENTS	DATES
Bell 47	Tail rotor blade	42	1963-81
Bell 47	Tail rotor blade yoke	7	1973-80
Bell 47	Connecting rod	5	1964-81
Bell 47	Main rotor stabilizer bar	3	1964-81
Bell 47	Tail rotor driveshaft	3	1965-81
Bell 204/205	Cross tube of landing gear floats	4	1968-80
Brantly B-2	Tail rotor blade	6	1965-81
Hiller 360/UH-12E	Connecting rod	4	1952-80
Hiller 360/UH-12E	Tail rotor blade	4	1966-81
Hughes 269	Tailboom	7	1970-81
Hughes 269	Lower coupling driveshaft	3	1967-81

Some of the fatigue problems have been on-going for a number of years, as for example the Bell 47 tail rotor blades (42 accidents in 18 years), the Hughes 269 tailboom (7 accidents in 11 years), and the Brantly B-2 tail rotor blades (6 accidents in 16 years).

4.3 Breakdown of Accidents by Year

Table 3 gives a yearly breakdown of the type of fatigue failures that have occurred in rotary-wing aircraft.

The total number of reported fixed-wing plus rotary-wing accidents occurring in each year is plotted in Figure 1. The big increase in the mid-1960s is the result of improved availability of accident information with the introduction of computer-based information systems in a number of countries (particularly the introduction of the US National Transportation Safety Board system in 1964). Over the last five years there has been an average of 100 fatal accidents (fixed-wing plus rotary-wing) per year resulting from metal fatigue.

The number of fixed-wing accidents for each year is plotted in Figure 2, while the number of rotary-wing accidents is shown in Figure 3. Averaged over the past five years, rotary-wing aircraft have had 31 serious accidents per year.

Figure 4 shows the breakdown of rotary-wing accidents by failure type. Since 1976, engine/transmission fatigue failures have been the most common accident cause, with 11 accidents per year on average, followed by tail rotor problems (7 per year), and failures in the main rotor system (4 per year).

4.4 Initiation Sites

The fatigue-crack initiation sites for the rotary-wing accidents are listed in Table 4. The identification numbers that are given can be used to look up the corresponding accident in Appendices J through P. Some failures are listed under more than one cause. For example, accident M29 in Appendix M was initiated by fretting at a bolt hole, so the accident is listed in Table 4 under "Fastener Hole", as well as "Fretting". The

initiation sites are summarized as follows:

<u>INITIATION SITE</u>	<u>NO. OF ACCIDENTS</u>
Bolt, stud or screw	32
Fillet, radius, or other stress concentration	22
Corrosion	19
Fastener hole or other hole	12
Fretting	10
Manufacturing defect or tool mark	9
Brinnelling, galling or wear	7
Thread (other than bolt or stud)	4
Weld	3
Subsurface flaw	3
Softened condition or subsurface decarburization	2
Surface scratch or damage	2

The above total does not equal the number of accidents in the survey, since information about the initiation site is unavailable in many cases.

4.5 Listing of Accidents by Country

Table 5 gives a cross-reference list of accidents by the country of occurrence. The identification numbers that are given can be used to look up the accident in Appendices J through P. The cross-reference list is in two parts - civil aircraft, and military aircraft. For military aircraft, the accidents are listed by owner (i.e., Canadian Forces), rather than by country of occurrence.

5.0 CONCLUSIONS

1. Although this survey does not claim to be comprehensive, a total of 1885 fixed-wing and rotary-wing aircraft accidents involving fatigue fracture since 1927 are covered by this survey. These accidents claimed 2240 fatalities worldwide. Furthermore, serious fatigue-related accidents are still occurring at a rate of about 100 per year.

2. Rotary-wing aircraft accounted for 419 accidents and 379 fatalities. Recently, there has been an average of about 31 rotary-wing fatigue accidents per year.

3. The common causes of rotary-wing fatigue failures over the past few years have been engine failure/transmission failure (averaging 11 per year), tail rotor (7 per year), and main rotor system (4 per year).

4. There are many cases of repeated accidents from the same cause. Ten examples are given of rotary-wing aircraft that have had at least three similar fatigue failures, one of which was recent. A more thorough review of the accident reports and Airworthiness Directives would be required in order to determine which of these problems are still on-

going and have not had sufficient action taken in order to arrest the problem.

5. The five most common initiation sites for fatigue cracks that have resulted in rotary-wing accidents are:

- (1) bolt, stud, or screw,
- (2) fillet, radius, or other stress concentration,
- (3) corrosion,
- (4) fastener hole or other hole, and
- (5) fretting.

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TABLE 1
SUMMARY OF ACCIDENTS - ROTARY-WING

<u>CATEGORY</u>	<u>NO.</u> <u>ACCIDENTS</u>	<u>NO.</u> <u>AIRCRAFT</u> <u>DESTROYED</u>	<u>NO.</u> <u>FATALITIES</u>
<u>ROTARY-WING AIRCRAFT</u>			
Engine or Transmission	136	40	44
Tail Rotor	100	43	81
Main Rotor System	55	31	167
Miscellaneous	45	18	22
Flight controls	37	18	34
Airframe	35	13	25
Landing Gear	11	2	6
	----	----	----
ROTARY-WING TOTALS	419	165	379
	----	----	----
FIXED-WING TOTALS	1466	393	1861
	----	----	----
OVERALL TOTALS			
(FIXED-WING + ROTARY-WING)	1885	558	2240

TABLE 2

LIST OF REPEATED FATIGUE FAILURES - ROTARY-WING

(Note: failure may not be in exactly same part)

<u>AIRCRAFT TYPE</u>	<u>NO. OF ACCIDENTS</u>	<u>FAILURE AREA</u>	<u>ACCIDENT DATES</u>	<u>IDENTIFICATION NUMBER OF ACCIDENTS</u>			
Bell 47	42	Tail rotor blade	1963-81	K2 K7 K15 K25 K32 K43 K57 K65 K78 K88 K95	K4 K8 K17 K27 K33 K44 K59 K67 K79 K90	K5 K12 K18 K28 K37 K47 K62 K69 K80 K91	K6 K14 K19 K29 K40 K55 K64 K77 K87 K94
Bell 47	7	Tail rotor blade yoke	1973-80	K39 K70	K51 K75	K53 K92	K60 L24
Hughes 269	7	Tailboom	1970-81	L10 L28	L12 L32	L19 L34	
Bell 47	6	Tail rotor retention bolt	1966-75	K16 K42	K22 K52	K23 K35	K34 K76
Brantly B-2	6	Tail rotor blade	1965-81	K9 K83	K30 K100		
Bell 47	5	Connecting rod	1964-81	N8 N102	N13 N134	N71	
Bell 47	5	Tail rotor drive- shaft assembly	1964-72	P3 P15	P11	P12 P14	
Bell 206A	5	Turbine blade	1970-75	N34 N68	N35	N36 N45	
Enstrom F-28	5	Tail rotor blade	1965-77	K10 K66	K31	K61 K63	
Bell 47	4	Tail rotor pitch control system (part unspecified)	1964-79	M2	M26	M27 M30	
Bell 204/205	4	Cross tube of landing gear floats	1968-80	O3	O6	O7 O10	
Bell 206B	4	Main rotor tension- torsion strap	1972-77	J25	J34	J36 J38	
Hiller UH-12E	4	Tail rotor blade	1966-81	K20	K26	K73 K98	
Hiller 360/UH-12E	4	Connecting rod	1952-80	N2	N16	N43 N119	
Hughes 269	4	Stabilizer	1965-75	L1	L3	L17 L22	
Bell 47	3	Main rotor blade grip	1960-72	J8	J21	J23	
Bell 47	3	Main rotor drag brace clevis	1970-79	J20	J46	J48	
Bell 47	3	Main rotor stabilizer bar	1964-81	J11	J22	J54	
Bell 47	3	Tail rotor driveshaft	1965-81	P4	P25	P42	

TABLE 2 (Cont'd)
LIST OF REPEATED FATIGUE FAILURES - ROTARY-WING

AIRCRAFT TYPE	NO. OF ACCIDENTS	FAILURE AREA	ACCIDENT DATES	IDENTIFICATION NUMBER OF ACCIDENTS		
Bell 47	3	Cooling fan blade	1950-72	N1	N15	N49
Bell 47	3	Connecting rod bolt	1963-73	N4	N38	N54
Bell UH-1H Iroquois	3	Tail rotor blade grip	1974-75	K45	K46	K58
Bell OH-58A	3	Compressor rotor	1973-74	N53	N61	N62
Hiller 360/UH-12E	3	Con rod bolt	1966-74	N17	N29	N59
Hughes 269	3	Lower coupling driveshaft	1967-81	N23	N56	N133
Sikorsky S-55	3	Tail boom pylon ring	1965-78	L2	L13	L31
Sikorsky S-61	3	MLG fitting	1963-77	O1	O2	O8
Sikorsky CH/HH-53	3	Main rotor blade	1960?-80?	J18	J19	J30
<hr/>						
Aerospatiale SA 318	2	Stabilizer spar tube	1974-75	L15	L20	
Bell 47	2	Tail rotor gearbox pinion shaft	1951-76	P1	P28	
Bell 47	2	Stabilizer spar tube	1970-76	L9	L26	
Bell 47	2	Tail rotor pitch change link	1967-76	M5	M17	
Bell 47	2	Piston pin	1967-68	N19	N25	
Bell 47	2	Conrod bearing	1974-77	N58	N85	
Bell 204B	2	Vertical fin	1968-77	L6	L27	
Bell 205A-1	2	Tail rotor pitch- change link	1974-78	M15	M28	
Bell 206	2	Main rotor trunnion	1977-80	J37	J50	
Bell 206B	2	Turbine blade	1979-80	N108	N124	
Bell 206A	2	Turbine wheel	1971-80	N37	N118	
Bell 206B	2	Pylon support link	1973	P19	P20	
Bell 214B-1	2	Engine accessory inner bevel gear	1977	N83	N89	
Bensen B-8M	2	Main rotor spindle	1964-67	J10	J13	
Boeing Vertol CH-47	2	Combining trans- mission spiral bevel gear	1974-79	N63	N106	
Brantly B-2	2	Connecting rod bolt	1965-69	N11	N27	
Brantly B-2	2	Tail rotor drive- shaft assembly	1967-73	P7	P22	
Brantly 305	2	Main rotor torsion strap (clevis bearings seized)	1967	J14	J15	
Brantly 305	2	Tail rotor hub	1973-75	K38	K56	
Enstrom F-28	2	Tail rotor drive- shaft	1978	P32	P33	
Fairchild Hiller FH-1100	2	Swashplate assembly	1969-74	M10	M14	
Fairchild Hiller FH-1100	2	Compressor blade	1972-79	N44	N109	
Hiller UH-12E	2	Wobble plate pylon, cyclic pitch control system	1965-76	M3	M18	
Hughes 269	2	Tail rotor blade	1964-75	K3	K48	

TABLE 2 (Cont'd)
LIST OF REPEATED FATIGUE FAILURES - ROTARY-WING

<u>AIRCRAFT TYPE</u>	<u>NO. OF ACCIDENTS</u>	<u>FAILURE AREA</u>	<u>ACCIDENT DATES</u>	<u>IDENTIFICATION NUMBER OF ACCIDENTS</u>	
Hughes 269	2	Connecting rod	1970-75	N32	N66
Hughes 269	2	Exhaust valve	1971-76	N39	N77
Hughes 269	2	Con rod bolts	1967-72	N22	N48
Hughes 369/500	2	Tail rotor hub	1977-78	K71	K81
Hughes 369	2	Compressor blade	1976	N74	N78
Hughes 369/500	2	Tail rotor drive flexible coupling	1979	P37	P38
Sikorsky S-55	2	Tail rotor pylon attach bolts	1968-78	L8	L30
Sikorsky S-55	2	Transmission support assembly	1972-79	P17	P39
Sikorsky S-61	2	Main rotor blade spindle lug	1978	J40	J41
Sikorsky Sea King	2	Transmission oil filter retaining bolt	1975-76	N70	N81
Sikorsky S-76	2	Main rotor spindle	1980-81	J51	J53

TABLE 3

BREAKDOWN OF ACCIDENT TYPES BY YEAR OF ACCIDENT - ROTARY-WING

<u>YEAR</u>	<u>MAIN ROTOR</u>	<u>TAIL ROTOR</u>	<u>AIRFRAME</u>	<u>FLIGHT CONTROLS</u>	<u>ENGINE/ TRANSMN</u>	<u>LANDING GEAR</u>	<u>MISC</u>	<u>TOTAL</u>
1937	1							1
1946	1							1
1947								0
1948								0
1949	1							1
1950				1	1			2
1951	1						1	2
1952					1			1
1953								0
1954								0
1955		1						1
1956								0
1957								0
1958								0
1959	1							1
1960	2							2
1961								0
1962								0
1963	1	1			3	1	1	7
1964	3	4		1	3		1	12
1965		7	2	1	3		1	14
1966		12	1	1	7	1	2	24
1967	3	3	2	1	5		3	17
1968	1	4	3	2	3	1	2	16
1969	1			4	5	1	1	12
1970	1	2	2	1	4			10
1971	2	1			4		2	9
1972	4	2	2	1	10		4	23
1973	1	7	2		7		4	21
1974	2	3	5	3	8	1	1	23
1975	4	12	5		8	1	4	34
1976	3	5	2	2	9		3	24
1977	2	8	3	5	13	2	1	34
1978	6	11	2	6	9	1	4	39
1979	5	8	1	1	8		4	27
1980	3	3		2	13	2	2	25
1981	3	6	2	4	12		3	30

TABLE 4

INITIATION SITES - ROTARY-WING

Bolt, Stud, or Screw (32 failures)

J39 K16 K22 K23 K34 K42 K52 K82 L1 L8 L21 L30 N3 N4
N7 N11 N17 N22 N27 N29 N48 N54 N59 N65 N70 N80 N105 N120
N131 N132 P16 P30

Fillet, Radius or Other Stress Concentration (22 failures)

J7 J50 K1 K8 K12 K14 K17 K18 K30 K35 K37 K76 K86 K88
K91 K94 L22 N77 N87 N107 N121 O1

Corrosion (19 failures)

J9 J20 J28 J29 J54 K26 K47 K48 K71 L16 M22 N74 N84 N90
N102 N120 N136 P30 P42

Fastener Hole or Other Hole (12 failures)

J1 J2 J17 K20 K68 M14 M16 M29 N115 O10 P6 P22

Fretting (10 failures)

J17 K26 L9 L10 L31 L34 M29 N43 N49 N115

Manufacturing Defect or Tool Mark (9 failures)

J13 J40 K28 K35 K54 K63 M16 N46 N121

Brinnelling, Galling, or Wear (7 failures)

J14 J53 M36 N58 N110 N119 P24

Thread (other than bolt or stud) (4 failures)

J8 J20 J51 K74

Weld (3 failures)

L14 L15 L33

Subsurface Flaw (3 failures)

N63 N123 P41

Softened Condition or Surface Decarburization (2 failures)

P32 P33

Surface Scratch or Damage (2 failures)

L24 N48

TABLE 5

LIST OF ACCIDENTS BY COUNTRY - ROTARY-WING

PART I. CIVIL AIRCRAFT

<u>AUSTRALIA</u>	K16	K65	K73	K88	K95	L6	L9	L11	M24	N57	N58	N65	N95
	N104	N105	N112	O9									
<u>BELGIUM</u>	J46	N1	N78										
<u>BRAZIL</u>	J51	K85											
<u>CANADA</u>	J8	J9	J17	J20	J25	J48	J50	K1	K2	K4	K20	K26	K35
	K90	K96	K97	L2	L8	L10	L31	L34	M9	M10	M20	M28	M36
	N6	N14-16	N24	N25	N28	N36	N73	N75	N76	N79	N83	N86	N109
	N118	N119	N121	N131	N132	N135	N136	P1	P2	P4	P6	P37	N4
<u>FINLAND</u>	K8	K67	L23										
<u>FRANCE</u>	K82	N2											
<u>GREENLAND</u>	O7												
<u>ICELAND</u>	K56	N69	P27										
<u>JAMAICA</u>	L5	N12											
<u>JAPAN</u>	K41	K71	L16	L22	L27	M22	M31	N74	N77	N87	N90	N102	N107
	N126											N122	
<u>NETHERLANDS</u>	J29												
<u>NEW ZEALAND</u>	K68	L19	L33	M19	M25	M29	N59	N115	P32	P33	P41		
<u>NIGERIA</u>	N51												
<u>NORWAY</u>	J41	P45											
<u>SOUTH AFRICA</u>	N129												
<u>SWEDEN</u>	N123												
<u>SWITZERLAND</u>	N49												
<u>THAILAND</u>	M37												
<u>UK</u>	J4	J53	K48	M1	N9	N40	P18	P30					
<u>USA (civil)</u>	too numerous to tabulate												
<u>WEST GERMANY</u>	J32	K42	K47	K51	K60	L15	L20	M23	M26	M27	M30	M35	
	N85	N91	P21	P25	P26	P40							

TABLE 5 (Continued)
LIST OF ACCIDENTS BY COUNTRY

PART 2. MILITARY AIRCRAFT

ROYAL AUSTRALIAN NAVY N70 N80 N88 N96 P36

BELGIAN AIR FORCE K99

CANADIAN FORCES J28 N63

JAPAN AIR SELF-DEFENCE FORCE P13

UK - ROYAL AIR FORCE P9

US ARMY J43 K45 K46 K50 K58 M33 N41 N42 N47 N50 N53 N61 N62
 N64 N67 N72 N100 N101 N106 N113 N117 O6 P15 P23 P31 P34

US COAST GUARD J40

US NAVY or US MARINE CORPS J30 P29

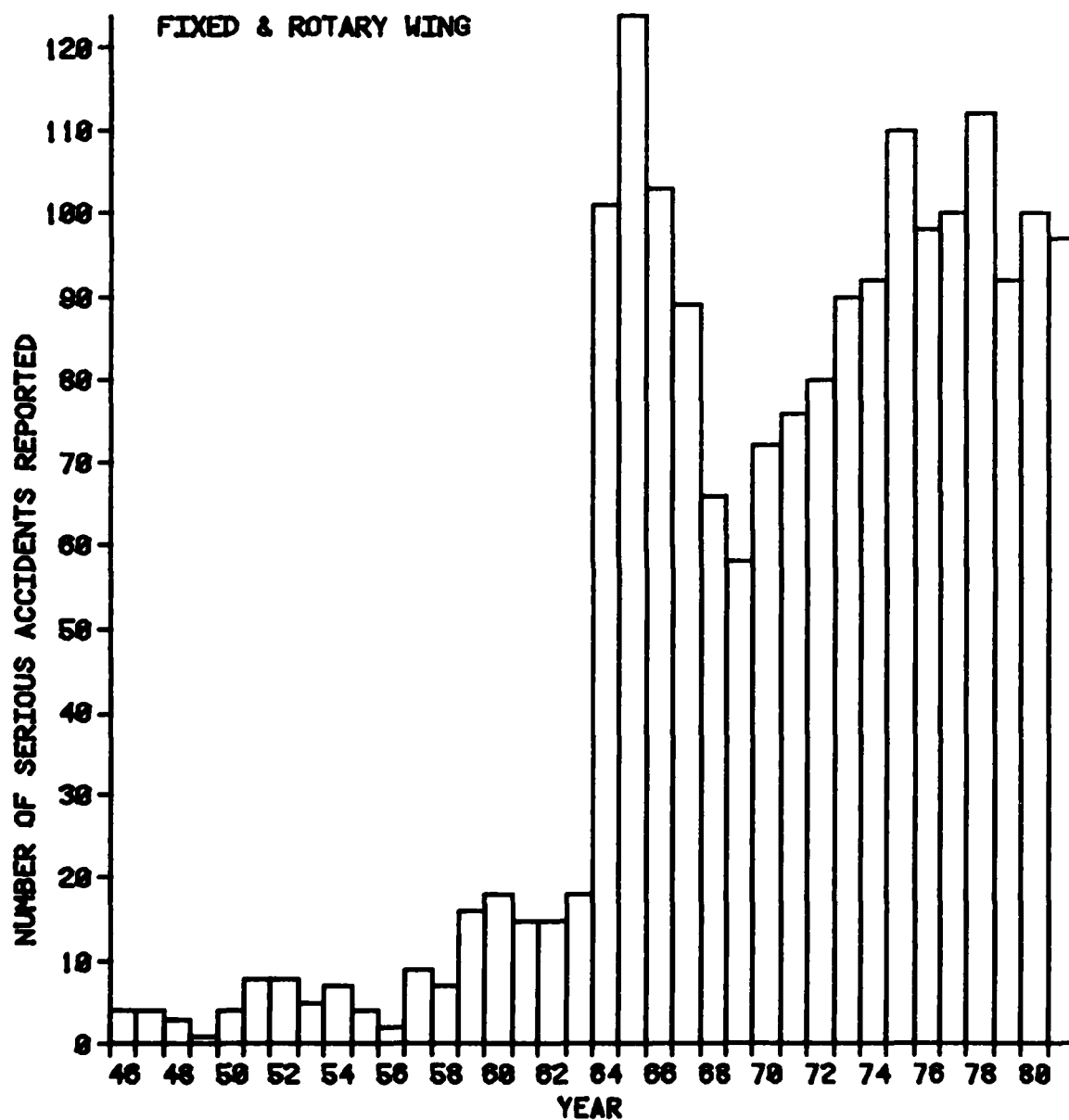
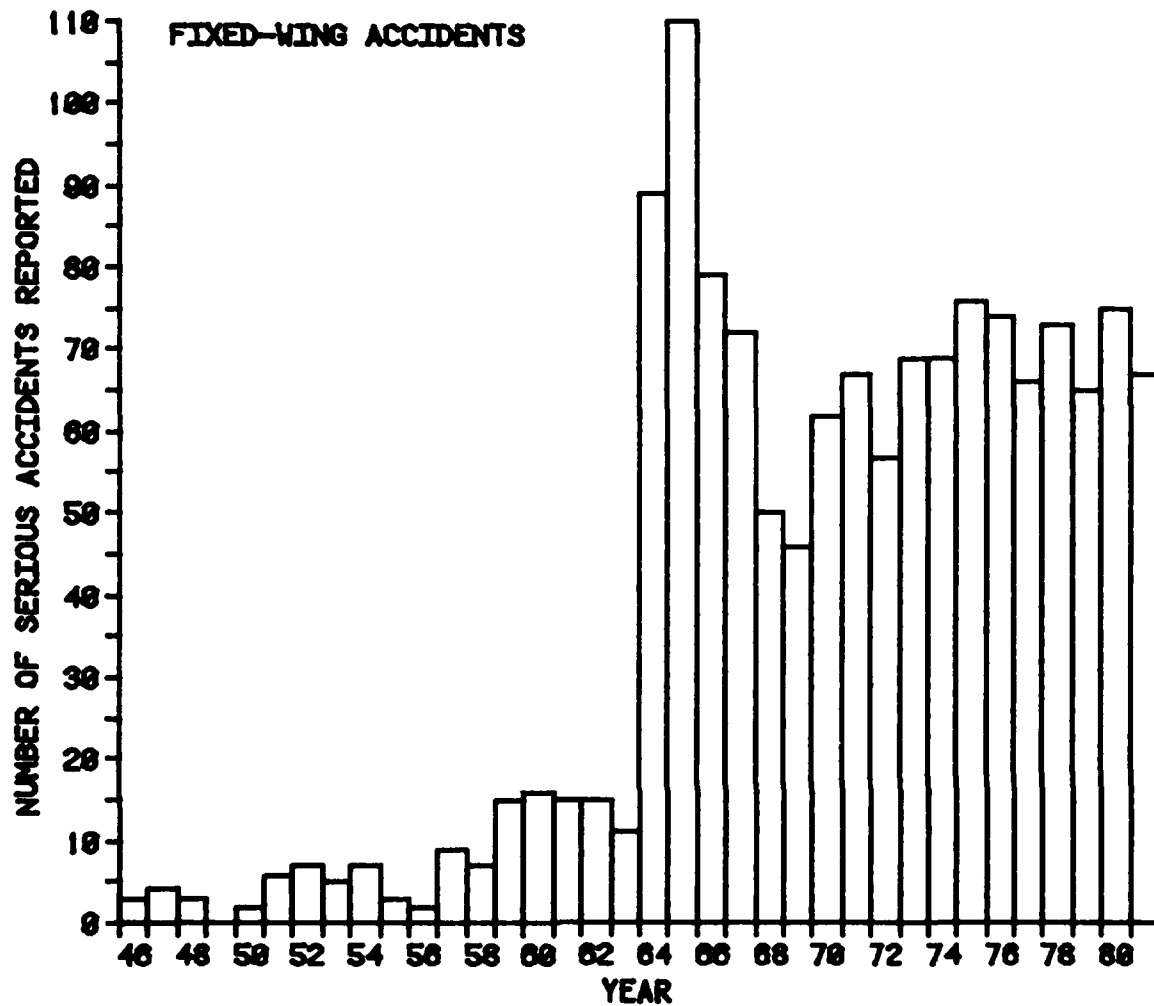
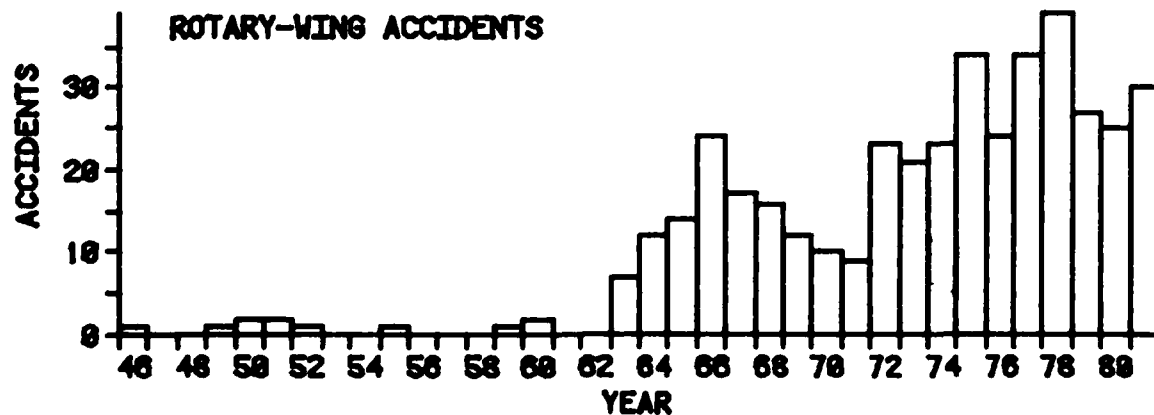


FIG. 1 NUMBER OF SERIOUS FATIGUE ACCIDENTS
- FIXED-WING & ROTARY-WING



**FIG. 2 NUMBER OF SERIOUS AIRCRAFT ACCIDENTS
- FIXED-WING**



**FIG. 3 NUMBER OF SERIOUS AIRCRAFT ACCIDENTS
- ROTARY-WING**

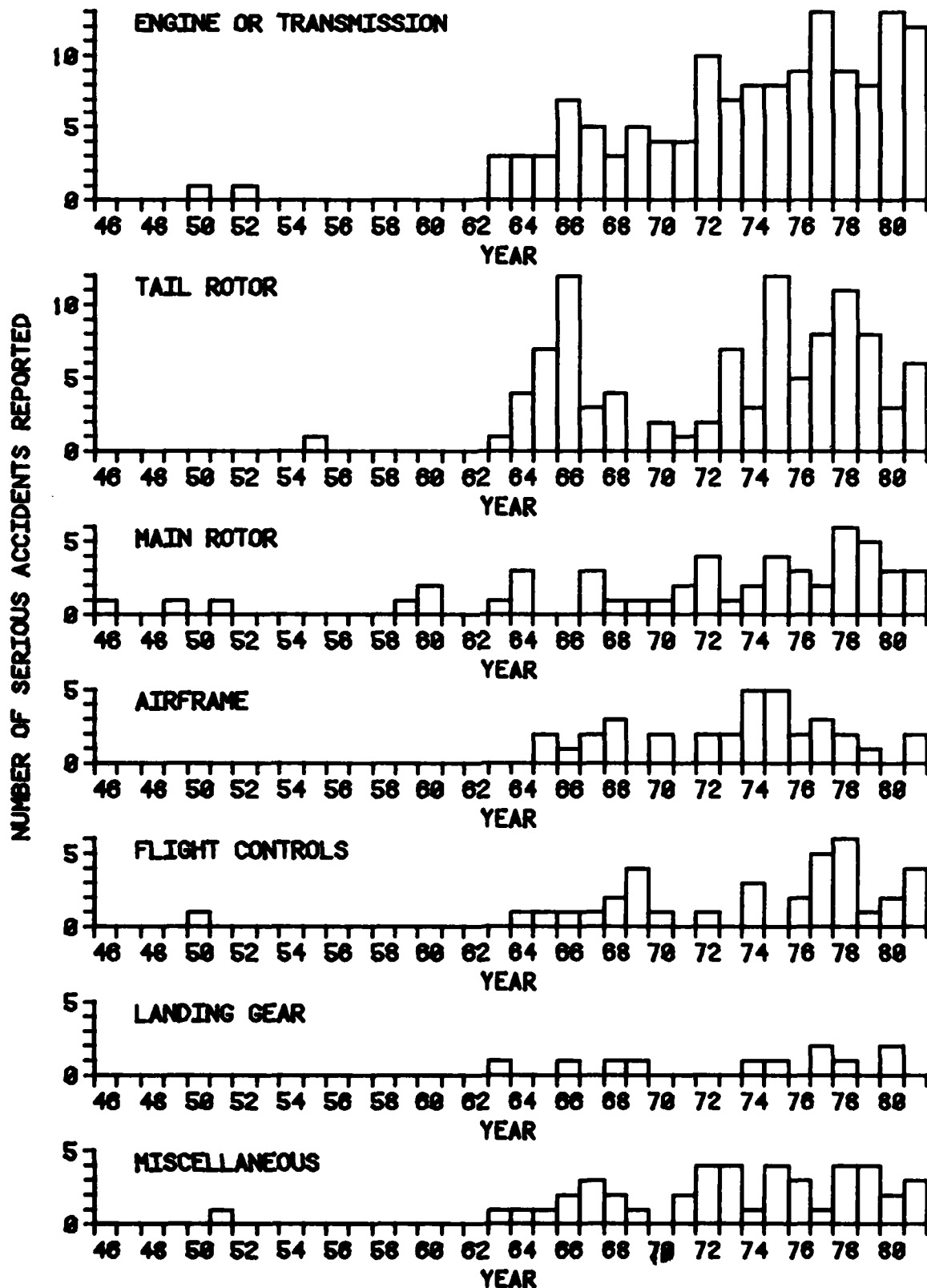


FIG. 4 CAUSES OF FATIGUE FAILURES - ROTARY-WING AIRCRAFT

MAIN ROTOR SYSTEM (ROTARY-WING)

 *
 * PART I *
 * LISTING BY FAILURE TYPE *
 *

 * APPENDIX J *
 *
 * ROTARY-WING - MAIN ROTOR SYSTEM *

ID No.	Aircraft Type	Accident Date	No. a Dead	D m	Remarks
J1	autogyro (USAF)	1937	0	D	USA. Main rotor blade at outboard pin hole of hub attachment. Ref: Sines, "METAL FATIGUE", pp 363-364.
J2	Type unknown (US helicopter)	1940-51	1?	? USA.	Main rotor link at lower lug. Origin: inside of hole at point where bushing ended. Ref: Bennett & Quick, NBS Circular 550, p 20.
J3	Type unknown (helicopter)	3 Apr 46	?	D USA?	Certified helicopter with less than 100 hours total time crashed. Failure of rotor hub. Ref: Dogherty & Spicer, "Helicopter Fatigue Substantiation Procedures for Civil Aircraft", ASTM STP 338, 1963.
J4	Fairey Aviation FB-1 Gyrodyne	17 Apr 49	2	D	Great Britain. Rotor hub. UK's 1st fatal helicopter crash. Ref: p 239, "A Century Journal". Royal Aeronautical Society 1866-1966".
J5	Sikorsky S-51 (Los Angeles Airways)	27 Aug 51	1	? Lynwood, Calif. USA.	Fatigue failure of flapping hinge of main rotor hub caused separation of blade. Ref: AW Jan. 14/52, p 13
J6	Vertol 44B (New York Airways)	12 May 59	0	S	New York, N.Y. USA. Tuning weight strap in forward rotor blade. Ref: WHAS p. 2.
J7	Sikorsky S-58C (Chicago Airways)	27 Jul 60	13	D	Forest Park, Ill. USA. Main rotor blade. Origin: lower external back-wall radius of spar. Ref: ICAO AAD #12, 1963, p 221.
J8	Bell 47G-2	27 Aug 60	0	D	Tremble Lake, Ont. Canada. Main rotor blade grip at barrel of grip (thread). Damaged in previous accident. Ref: MoT Canada file 1100.

J-2

MAIN ROTOR SYSTEM (ROTARY-WING)

J9 Vertol 42A H-21B Work Horse	17 Oct 63	0	S	Brass Radio Station, Que. Canada. Rear green main rotor blade at tubular spar 3 feet outboard of rotor head. (Corrosion pits). Ref: MoT Canada file 2128.
J10 Bensen B-8M Gyro-Copter	19 Jun 64	1	D	Nacogdoches, Tex. USA. Spindle holding main rotor to mast. Ref: NTSB file 2-1006
J11 Bell 47J-2	29 Jun 64	0	S	Waltham, Mass. USA. Main rotor mast control stabilizer bar. Ref: NTSB file 2-0699.
J12 Hughes 269A	14 Oct 64	2	D	Houston, Texas USA. Main rotor. Lack of lubrication in bearings. Ref: NTSB file 2-0974
J13 Bensen B-8M Gyro-Copter	28 Jan 67	1	D	Chino, Calif. USA. Main rotor separated in flight. Rotor spindle not made to specifications. NTSB file 2-0030
J14 Brantly 305	29 May 67	2	D	Chamblee, Ga. USA. Brinelled main-rotor hub clevis bearings caused torsion strap assembly to fail in fatigue, & main rotor separated. Ref: NTSB file 2-1188
J15 Brantly 305	3 Nov 67	3	D	Taswell, Ind. USA. Main rotor clevis bearings seized, main rotor torsion straps failed, causing main rotor to separate. Ref: NTSB file 2-1092
J16 Sikorsky S-61L (Los Angeles Airways)	14 Aug 68	21	D	Compton Calif. USA. Failure of shank of yellow main rotor blade spindle, causing separation of blade. Material: 4340 steel. Ref: NTSB file 1-0016
J17 Hiller FH-1100	15 Nov 69	0	S	Nordegg, Alta. Canada. Lower tine of main rotor blade cuff, at blade retention bolt hole (fretting). Undertorquing of main rotor retention bolt. Ref: MoT Canada file 5002-4637.
J18 Sikorsky CH/HH-53	late 1960s to 1980	?	?	?
				Spar of main rotor blade. Ref: AWST 29 Sept/80 p 85; OTTAWA CITIZEN, Dec 12/80, p 97.
J19 Sikorsky CH/HH-53	late 1960s to 1980	?	?	?
				Spar of main rotor blade. Ref: AWST 29 Sept/80 p 85; OTTAWA CITIZEN, Dec 12/80, p 97.
J20 Bell 47G-2	7 Apr 70	0	S	Timmins, Ont. Canada. Main rotor blade drag brace clevis. (Corrosion fatigue). Threads. Ref: MoT Canada file 00020.

J-3
MAIN ROTOR SYSTEM (ROTARY-WING)

J21 Bell 47G-2	8 Jun 71	1	D	Branchville, N.J., USA. Main rotor blade & grip assembly separated in flight. Improper grip for Bell 47G-2. Role: aerial application. NTSB file 3-1465
J22 Bell 47G-3B	8 Sep 71	0	S	Brentwood, Cal. USA. Main rotor stabilizer bar. NTSB file 3-3250.
J23 Bell 47G-2	20 Mar 72	0	S	Fremont, Iowa. USA. Main rotor blade grip. NTSB file 3-0475.
J24 Boeing Vertol CH-47A Chinook (US Army)	10 May 72	34	D	Vn. USA. Aft green main rotor blade (spar). Ref: US Army.
J25 Bell 206B	10 Aug 72	4	S	Embar, Labrador, Canada. Main rotor-blade retention strap fitting. Ref: MoT Canada file A20018
J26 Brantly B-2B	15 Aug 72	2	D	Duxbury, Mass. USA. Red main rotor blade separated in flight. Ref: NTSB file 3-1189
J27 Bell AH-1G HueyCobra (US Army)	26 Nov 73	2	D	Ok. USA. Main rotor blade assembly. Ref: US Army.
J28 Boeing Vertol CH 113A Voyager (Canadian Forces)	20 Mar 74	3	D	Edmonton, Alta. Canada. Forward red rotor blade. Origin: corrosion pit on main D spar at mid-chord. Ref: CFAIRS.
J29 Sikorsky S-61N (KLM Noordzee)	10 May 74	6	D	North Sea, 110 nm n. of Texel, Netherlands. Separation of no. 3 main rotor blade. Origin: corrosion at bottom of spar. Ref: Netherlands Dept. of Civil Aviation.
J30 Sikorsky CH-53D Sea Stallion (US Marines)	8 Jan 75	4	?	Salisbury, Md. USA. Main rotor blade. Ref: OTTAWA CITIZEN, 11 Dec. 1980.
J31 Bell 206A	1 Feb 75	1	D	Milford, Connecticut, USA. Main rotor separated in flight. Lower main rotor pitch-change mechanism clevis. Ref: NTSB file 3-0335
J32 Bell 206A	23 Oct 75	4	D	Hiddensen, West Germany. Main rotor blade. Ref: West German file 3X0474.
J33 Bell 212	3 Nov 75	9	D	Gulf of Mexico, near Louisiana USA. Main rotor blades separated. NTSB file 3-4119.
J34 Bell 206B	17 Apr 76	1	D	Leeville, La. USA. Main rotor tension-torsion strap failed, causing rotor failure. Ref NTSB file 3-3102

J-4

MAIN ROTOR SYSTEM (ROTARY-WING)

J35 Air & Space 18-A	16 Feb 76	0	S	Baton Rouge, La. USA. Main rotor blade drag strut link. Ref: NTSB file 3-0171.
J36 Bell 206B	11 Dec 76	0	S	Morgan City, La. USA. Main rotor tension torsion strap separated. NTSB file 3-3870.
J37 Bell 206B	18 Feb 77	0	S	Atlanta, Ga. USA. Main rotor trunnion separated. NTSB file 3-0710.
J38 Bell 206B	17 Mar 77	1	D	Intracoastal City, La. USA. Main rotor tension-torsion strap. Ref: NTSB file 3-4230
J39 Bell 47G-4A	23 Mar 78	2	D	Morgan City, La. USA. Main rotor failure. Rotor blade counter-weight rod tie-bolt failed. Ref: NTSB file 3-0795
J40 Sikorsky S-61R (US Coast Guard)	May 78	?	?	USA Main rotor blade separated. Origin: fault in plating of spindle lug bore. Ref: AWST Aug 7/78 p 24, FI 24 Mar/79 p 888, & HELICOPTER INTER- NATIONAL Dec/79-Jan/80 p 90.
J41 Sikorsky S-61N (Helikopter Service)	26 Jun 78	18	D	North Sea, off Norway. Lost a main rotor blade. Failure of rear lug on no. 5 main rotor blade spindle. Ref: Norwegian Civil Aviation Administration
J42 Sikorsky S-76A	28 Jul 78	0	S	W. Palm Beach, Fla. USA. Main rotor failure (quill shaft). Ref: NTSB file 3-2896.
J43 Bell OH-58A Kiowa (US Army)	25 Aug 78	3	D	Germany. Main rotor blade assembly. Ref: US Army.
J44 Sikorsky S-58ET	1 Oct 78	1	D	Steamboat Springs, Colo. USA. Main rotor hinge pin. Ref: NTSB file 3-3296.
J45 Hiller UH-12E	11 May 79	0	S	Independence, Ore. USA. Main rotor failed. Incidence push rod end bearing failed at outer shell. NTSB file 3-1767
J46 Bell 47G-2	2 Aug 79	0	D	Neufchateau, Belgium. Clevis of one drag brace of main rotor blade. Ref: Belgium AA.
J47 Hiller UH-12E	10 Aug 79	0	S	Tuscaloosa, Al. USA. Pin, main rotor, outboard, tension torsion bar. Ref: NTSB file 3-3708.

MAIN ROTOR SYSTEM (ROTARY-WING)

J48 Bell 47G-2	24 Aug 79	0	S	Niagara Falls, Ont. Canada. Main rotor drag brace fitting. Ref: MoT Canada file 090106.
J49 Sikorsky CH-54A Tarhe (US Army)	29 Sep 79	4	D	Oh. USA. Main rotor separated (horizontal pin). Ref: US Army.
J50 Bell 206L	9 Jan 80	0	S	Opinaca, Que. Canada. Main rotor trunnion. Origin: spindle fillet. Lack of tempering during manufacture. Ref: MoT Canada file 80-Q00002.
J51 Sikorsky S-76A (VOTEC)	20 Mar 80	14	D	Off the Brazil coast. Inboard spindle bearing became displaced, causing fracture of main rotor head spindle (thread at spline inboard end). Ref: AWST May 5/80, p 23; HELICOPTER INTL., June-July/80 p 21
J52 Bell 47G-2A	3 Sep 80	2	D	Cottonport, La. USA. Main rotor failure. Cyclic-pitch lateral torque tube pivot shaft failed. Ref: NTSB file 3-2504
J53 Sikorsky S-76A (Bristow Helicopters)	13 Mar 81	4	D	North Sea, Aberdeen, Scotland. Excessive wear on Teflon-impregnated outer bearing caused main rotor spindle to crack at inboard end. Ref: AWST 23 Mar/81 p 26; & FI 2 May 81 p 1223
J54 Bell 47G-5	12 Jun 81	0	S	Coloma, Wi. USA. Main rotor separated. Corrosion and fatigue fracture of stabilizer bar assembly. Ref: NTSB file 3-1340.
J55 Robinson R22	Fall 81	?	?	Ellington, Conn. USA. Failure of Al61 rotor fitting. Ref: ROTOR & WING INTL., Jan. 82 p 62

Total Fatalities: 167

* APPENDIX K *
* ROTARY-WING - TAIL ROTOR *

ID No.	Aircraft Type	Accident Date	No. a Dead	Remarks
K1	Bell 47B	2 Jun 55	2 D	Chapleau, Ont. Canada. Tail rotor hub. Origin: bottom of inboard undercut radius of spindle. Blade, blade grip & spindle separated. Cracks in copper plating. Ref: MOT Canada file 55-33.
K2	Bell 47G-2	4 Sep 63	0 S	Stewart, B.C. Canada. Tail rotor blade at thrust side of bore of blade hub. Ref: MOT Canada file 2107.
K3	Hughes 269A	9 Feb 64	0 S	Opa Locka, Fla. USA Tail rotor blades. Ref: NTSB file 2-0032
K4	Bell 47G	3 May 64	0 D	McFarlane Lake, Ont. Canada. Tail rotor blade grip. Ref: MOT Canada file 2233.
K5	Bell 47G	27 Jul 64	0 S	Plymouth, Mass. USA. Tail rotor blade. Ref: NTSB file 2-0609
K6	Bell 47J-2	7 Dec 64	3 D	Venice, La. USA. Separation of tail rotor blade, blade grip. Ref: NTSB file 2-0990
K7	Bell 47J-2	28 Mar 65	1 D	Boston, Mass. USA. Tail rotor blade at blade grip. Ref: NTSB file 2-0282
K8	Agusta-Bell 47J	6 Jun 65	3 ?	Helsinki, Finland. Tail rotor separated. Fracture in groove on thrust-bearing seat of blade grip. Ref: Finland National Board of Aviation.
K9	Brantly B-2	28 Jun 65	0 S	Prophetstown, Ill. USA. Tail rotor blades (unapproved mod). Ref: NTSB file 2-0638.
K10	Enstrom F-28	11 Jul 65	0 S	Marquette, Mich. USA. Tail rotor blades. Ref: NTSB file 2-0496
K11	Brantly 305	23 Aug 65	0 S	Millheim, Pa. USA. Tail rotor blades. Ref: NTSB file 2-0640
K12	Bell 47G-2	23 Nov 65	0 S	Kelso, Wash. USA. Tail rotor blade inside grip fitting in stress relief fillet. Ref: NTSB file 2-1079.

K-2

TAIL ROTOR (ROTARY-WING)

K13 Bell 47J-2	9 Dec 65	0	S	Refugio, Tex. USA. Tail rotor pinion shaft (improper assembly). Herding cattle. Ref: NTSB file 2-1005
K14 Bell 47J-2	14 Jan 66	0	S	East Boston, Mass. USA. Tail rotor blade inside grip fitting in stress relief fillet. Ref: NTSB file 2-0291.
K15 Bell 47G-4	31 Jan 66	0	S	Burbank, Cal. USA. Tail rotor blade. Ref: NTSB file 2-0351.
K16 Bell 47G-2	10 Feb 66	3	?	Sydney, Australia. Tail rotor retention bolt. Ref: Australia DoT.
K17 Bell 47G-2	19 Feb 66	0	S	Gold Hill, N.C. USA. Tail rotor blade in grip fitting stress relief fillet. Ref: NTSB file 2-0438.
K18 Bell 47G-3B-1	20 Mar 66	0	S	Fredericksted, Vi. USA. Tail rotor blade inside grip fitting in stress relief fillet. Ref: NTSB file 2-0439
K19 Bell 47G-3B	20 Jul 66	0	S	Santa Ana, Cal. USA. Tail rotor blade. Ref: NTSB file 2-0672
K20 Hiller UH-12E	22 Jul 66	2	D	Cochrane, Ontario, Canada. Tail-rotor spar. Origin: lower outboard trunnion attachment bolt hole. Ref: Canada MoT
K21 Bell 204B	8 Oct 66	11	D	Morgan City, La. USA. Tail rotor. NTSB file 2-1140
K22 Bell 47D-1	11 Oct 66	0	S	Ellensburg, Wash. USA. Tail rotor hub retention bolt. NTSB file 2-1001
K23 Bell 47G	12 Oct 66	0	S	Tonasket, Wash. USA. Tail rotor hub assembly bolt. NTSB file 2-1029.
K24 Hiller UH-12C	2 Nov 66	0	S	Mineral Wells, Tex. USA. Tail rotor hub. Ref: NTSB file 2-1014
K25 Bell 47J-2	7 Nov 66	4	D	Carpenter, Calif. USA. Tail rotor blade. Ref: NTSB file 2-1170
K26 Hiller UH-12E	2 Sep 67	2	D	Near Ft. Nelson, B.C. Canada. Tail-rotor spar tube. Origin: fretting corrosion. Ref: MoT file 3623.
K27 Bell 47G-4	13 Sep 67	2	S	La Place, La. USA. Shell of tail rotor blade. NTSB file 2-1036.
K28 Bell 47J-2A	13 Dec 67	2	D	Hanalei, Hawaii, USA. Tail rotor blade. Lack of bonding material between shell and grip. Ref: NTSB file 2-1121

K-3
TAIL ROTOR (ROTARY-WING)

K29 Bell 47G-4A	3 Jan 68	0	D Los Angeles, Calif. USA. Tail rotor blade. Role: police patrol. Ref: NTSB file 3-0657.
K30 Brantly B-2B	6 Feb 68	2	D Lakeside Nebr. USA. Tail-rotor blade spar, inside bearing boss radius. Ref: NTSB file 3-1563
K31 Enstrom F-28	10 May 68	0	S Milwaukee, Wis. USA. Rotor spindle of tail rotor. NTSB file 3-2337.
K32 Bell 47G-4A	26 Oct 68	0	S Chicago, Ill. USA. Tail rotor blades. Ref: NTSB file 3-4203
K33 Bell 47J-2	10 Jan 70	2	D Fairbanks, Alaska USA. Tail rotor blades separated. NTSB file 3-0839.
K34 Bell 47G-2	14 Aug 70	0	S Panama City, Fla. USA. Tail rotor blade retaining bolt. Ref: NTSB file 3-3191.
K35 Brantly B-2	12 Jun 71	0	S Middleton, N.S. Canada. Tail rotor blade. Origin: inner wall surface of grip at thrust bearing shoulder relief radius (tool mark). Ref: MOT Canada file A1007.
K36 Bell 205A-1	29 May 72	11	D Dulac, La. USA. Tail rotor blade grips failed. NTSB file 3-0659
K37 Bell 47G-3B-1	30 Aug 72	1	D Tuba City, Ariz. USA. Tail rotor blades. Origin: internal bearing shoulder. Ref: NTSB file 3-3336
K38 Brantly 305	23 May 73	0	S Denver, Colo. USA. Tail rotor hub. Ref: NTSB file 3-4173.
K39 Bell 47D	7 Jul 73	0	S Anacortes, Wash. USA. Tail rotor blade yoke. Ref: NTSB file 3-2998.
K40 Bell 47G-5	8 Jul 73	0	S Albuquerque, N. Mex. USA. Fracture of tail rotor blade. Previous damage to tail rotor pitch control system (75% of wires, cable #1, damaged by wear). NTSB file 3-2590.
K41 Kawasaki KH-4	14 Jul 73	0	D Chiba Pref., Japan. Rear edge fitting on parts of tail rotor blade. Ref: Japan MoT.
K42 Agusta 47G-2	8 Sep 73	2	D Solingen, West Germany. Separation of tail rotor, failure of bolt. Allowable flight time on blade exceeded. Ref: West German file 3X0423.

K-4

TAIL ROTOR (ROTARY-WING)

K43 Bell 47G-2	18 Sep 73	0	S	Viola, Ark. USA. Tail rotor blade (blade grip area). Ref: NTSB file 3-3346.
K44 Bell 47G-5	4 Oct 73	0	S	Fresno, Cal. USA. Tail rotor blade. Ref: NTSB file 3-3930.
K45 Bell UH-1H Iroquois (US Army)	23 Jul 74	0	S	Mo. USA. Tail rotor grip. Ref: US Army.
K46 Bell UH-1H Iroquois (US Army)	19 Aug 74	0	S	Fl. USA. Tail rotor at blade grip. Ref: US Army.
K47 Bell 47G-2	21 Oct 74	1	D	Hullern, West Germany. Separation of tail rotor due to fracture at blade root. Initiated by corrosion. Ref: W. German file 3X0454.
K48 Hughes 269C	15 Jan 75	2	D	Barnby Moor, Notts., England. Tail rotor spar (corrosion pit). Ref: FI 8 May/76 p. 1235.
K49 Hughes 369HS	20 Feb 75	0	S	Grand Chenier, La. USA. Tail rotor blade. NTSB file 3-1743.
K50 Bell UH-1H Iroquois (US Army)	13 May 75	0	S	In. USA. Tail rotor (stiffener spar). Ref: US Army.
K51 Agusta 47G-2	20 May 75	0	D	Feldkirchen, W. Germany. Tail rotor blade yoke. Ref: W. German file 3X0136.
K52 Bell 47H-1	20 May 75	0	S	Nashville, Tenn. USA. Tail rotor hub bolt. 499.8 hours on bolt (retirement life: 600 hours). NTSB file 3-2734.
K53 Bell 47G-2	26 May 75	0	S	Denmark, Ar. USA. Yoke tail rotor hub. Ref: NTSB file 3-1381.
K54 Bell 47G-2	2 Jul 75	1	D	Napa, Calif. USA. Improperly-machined tail rotor hub failed, blade separated from rotor yoke. Role: crop dusting. Ref: NTSB file 3-0266
K55 Bell 47G-2A	20 Jul 75	0	S	Freer, Tex. USA. Tail rotor blade. Ref: NTSB file 3-2431.
K56 Brantly B-305	31 Jul 75	0	D	100 km from Reykjavik, Iceland. Tail rotor (blade hub). Possibly improper installation. Ref: Iceland.
K57 Bell 47G-5	10 Aug 75	0	S	Chandler, Ariz. USA. Tail rotor blade. Ref: NTSB file 3-2127.

K-5
TAIL ROTOR (ROTARY-WING)

K58 Bell UH-1H Iroquois (US Army)	22 Aug 75	0	D Ky. USA. Tail rotor grip assembly. Ref: US Army.
K59 Bell 47G-2	26 Aug 75	0	S Elliott, S.C. USA. Tail rotor grip. Ref: NTSB file 3-4165.
K60 Bell 47G-2	21 Jan 76	0	D Bad Friedrichsh. W. Germany. Tail rotor yoke. Ref: W. German file 3X0007.
K61 Enstrom F-28A	4 Apr 76	0	S Blythe, Cal. USA. Tail rotor blade. Ref: NTSB file 3-1699.
K62 Bell 47G-3B-1	17 Jul 76	2	D Petersburg Arkansas, USA. Tail rotor separated. Rotor blades 22 hours past mandatory change time. Ref: NTSB file 3-3890
K63 Enstrom F-28A	9 Aug 76	2	D Enon, Ohio USA. Tail rotor blades separated. Spindle machined below specifications, and tool marks in machined area. NTSB file 3-4077
K64 Bell 47G-2	6 Nov 76	1	D Pigeon Forge, Tenn. USA. Tail rotor blade. Ref: NTSB file 3-3404
K65 Bell 47G-2	1977	0	S Bullo River, NT, Australia. Blade thrust bearing & blade grip failure. Prior damage to bearing. Ref: Australia DoT.
K66 Enstrom F-28C	8 Jan 77	0	S Fallentimber, Pa. USA. Tail rotor spindle. Ref: NTSB file 3-2150.
K67 Bell 47D	29 Apr 77	0	S Pori, Finland. Tail rotor blade. Ref: Finland BoA.
K68 Hiller UH-12E	6 May 77	0	S Camerons Creek, New Zealand. Cuff (cuff & trunnion assembly of tail rotor) at bolt hole. Ref: NZ brief 77-071.
K69 Bell 47G-5A	6 May 77	0	D Russiaville, In. USA. Tail rotor blade. Role: aerial application. Ref: NTSB file 3-3990
K70 Bell 47G-2	14 Jun 77	0	S Santa Monica, Cal. USA. Tail rotor, yoke rotor hub in tail rotor gear box. Ref: NTSB file 3-2986.
K71 Hughes 369H	25 Jul 77	0	D Hiroshima Pref. Japan. Tail rotor hub failed (maraging steel). Origin: pitting corrosion. Ref: Japan MoT
K72 Enstrom F-28	31 Jul 77	0	S Montgomery, Ala. USA. Reversed installation of bearing in tail rotor pitch control system caused tail rotor failure. Ref: NTSB file 3-2386.

K-6

TAIL ROTOR (ROTARY-WING)

K73 Hiller UH-12E	1978	0	D Wyndham, Australia. Tail rotor blade separated. Ref: Australia DoT
K74 Hughes 269B	10 Feb 78	0	D Tahola, Wa. USA. Tail rotor swashplate assembly at threads. Ref: Ref: NTSB file 3-0349.
K75 Bell 47G-1	18 Feb 78	0	S Buttonwillow, Cal. USA. Yoke tail rotor hub. Ref: NTSB file 3-0214.
K76 Brantly B-2B	14 Jul 78	1	S Nome, Alaska USA. Tail rotor blade at radius inboard of thrust bearing shoulder. Role: herding animals. Ref: NTSB file 3-4406.
K77 Bell 47G	15 Jul 78	1	D Loughman, Florida USA. Tail rotor blade. Time on blade: 77.5 hours. Role: crop dusting. Ref: NTSB file 3-4193 & Safety Recommendations A-80-30 & -31.
K78 Bell 47G-2	16 Jul 78	0	S Pigeon Forge, Tenn. USA. Tail rotor blade grip. Ref: NTSB file 3-3357.
K79 Bell 47G-2	12 Aug 78	0	S Soledad, Cal. USA. Tail rotor blade at insert on shank. Ref: NTSB file 3-2427.
K80 Bell 47G-2	12 Aug 78	1	D Omega, Georgia USA. Tail rotor blades. Role: crop spraying. Ref: NTSB file 3-4257
K81 Hughes 369D	14 Aug 78	0	D Cascadia, Oregon USA. Tail rotor hinge bearings worn. Vibration allowed tail rotor hub to fail. Role: logging. Ref: NTSB file 3-4204
K82 Bell 214	11 Nov 78	1	D Col de M'rie Blan, France. Tail rotor with its rear transmission box separated. Vibration caused by flapping of tail rotor as a result of abnormal wear of a universal joint. 3 fastening bolts on tail rotor broke in fatigue. Ref: WAHS p 26
K83 Brantly B-2B	15 Dec 78	2	D Sloan, Iowa USA. Tail rotor blade. NTSB file 3-4376
K84 Rotorway Scorpion Too	27 Mar 79	1	S Johns Island, S. Carolina, USA. Tail rotor blades separated. NTSB file 3-2385.
K85 Sikorsky S-58ET	16 Mar 79	0	D Nova Vicosia, Brazil. Tail rotor blade. Ref: Brazil.
K86 Sikorsky S-61L (N.Y. Airways)	18 Apr 79	3	D Newark, N.J. USA. Tail rotor blade separated. Crack in leading- edge spar. Ref: NTSB file 1-0013 & NTSB-AAR- 79-14.

K-7
TAIL ROTOR (ROTARY-WING)

K87 Bell 47D	8 Jun 79	0	S	Parchman, Miss. USA. Tail rotor blade. NTSB file 3-1957.
K88 Bell 47G-2	17 Jun 79	2	D	Jundah, Qld. Australia. Tail rotor blade grip at relief radius of outer bearing. Ref: Australia DoT
K89 Bell 206B	21 Jul 79	0	S	Alpine, N.J. USA. Fatigue fracture of tail rotor blade. ELT antenna separated due to fatigue. Tail rotor grooves match ELT antenna. NTSB file 3-3911.
K90 Bell 47G	30 Jul 79	0	S	St. Andrews, Man. Canada. Tail rotor at blade grip. Ref: MOT Canada file C90095.
K91 Bell 47J-2	14 Sep 79	5	D	Long Beach, Calif. USA. Tail rotor separated. Origin: inside diameter of blade grip. Ref: NTSB file 3-3068 & Safety Recommendations A-80-30 & -31.
K92 Bell 47G-2	8 Mar 80	0	D	Brentwood, Calif. USA. Tail rotor blade yoke. Role: spraying. Ref: NTSB file 3-3256.
K93 Tom Cat I	1 May 80	0	D	Watsonville, Ca. USA. Tail rotor blade. Blade was 632 hours beyond required removal time. Role: crop spraying. Ref: NTSB file 3-1634
K94 Bell 47D-1	22 Jul 80	0	S	Milan, Mi. USA. Tail rotor blade at outboard bearing relief radius of grip. NTSB file 3-2462
K95 Bell 47	1981	0	S	Stanthorpe, Queensland Australia. Tail rotor at blade grip. Ref: Australia DoT.
K96 Bell 47G-2	20 Feb 81	0	S	Abbotsford, B.C. Canada. Tail rotor blade grip. Service life 300 hours. Blade had been on 3 different helicopters for a total of 1308 hours. MOT Canada file P10011.
K97 Aerospatiale AS 350 Astar	27 Feb 81	0	S	St. Faustin, Que. Canada. Tail rotor failure (tail rotor control fitting). Fitting not properly seated on tail rotor blade flange. Ref: MOT Canada file Q10010
K98 Hiller UH-12E	3 Apr 81	0	D	Miami, Fl. USA. Tail rotor blade failure. Bogus part. Blade composed of impure skin material, rivets installed incorrectly, & bal. screw not lock-wired. Ref: NTSB file 3-1902.
K99 Westland Sea King HAS Mk.1 (Belgian AF)	28 Apr 81	0	S	Oostende, Belgium. Lug of tail rotor blade fitting. Ref: Belgium AA.

K-8

TAIL ROTOR (ROTARY-WING)

K100 Brantly
B-2B

10 Jun 81

2 D Chesterton, In. USA.

Tail rotor blade (blade shank outboard of
double bearing location). Ref: NTSB file 3-1489

Total fatalities: 81

L-1
AIRFRAME (ROTARY-WING)

* APPENDIX L *
* ROTARY-WING - AIRFRAME *

ID No.	Aircraft Type	Accident Date	No. a Dead m	Remarks
L1	Hughes 269A	19 Aug 65	0 S	Miami, Fla. USA. Looseness of stabilizer lower attach bolt caused upper attach bolt to fatigue fail, stabilizer came off. Ref: NTSB file 2-0552.
L2	Sikorsky S-55	15 Oct 65	0 S	Fogo Village, Nfld. Canada. Tail rotor pylon lower attachment ring. (Magnesium alloy casting). Ref: MOT Canada file 2747.
L3	Hughes 269B	1 Mar 66	0 S	Memphis, Tenn. USA. Loose tail rotor abrasive strip caused vibration, failing improper rivets in stabilizer mount bracket. Ref: NTSB file 2-0358.
L4	Bell 47G	26 Jun 67	0 S	Lincoln, Kans. USA. Tail rotor assembly broke off tail boom due to failure of housing yoke. Ref: NTSB file 2-0889.
L5	Sikorsky S-52-3	28 Jun 67	0 S	Kingston, Jamaica. Tail rotor separated. Tail cone pylon tube separated at station 72. Ref: Jamaica.
L6	Bell 204B	22 Mar 68	3 ?	Bass Strait, Australia. Tail fin structure (tail rotor imbalance). Trunnion thrust washer not installed during maintenance. Australian DoT
L7	Brantly B-2B	6 Jul 68	0 S	Monroeville, Pa. USA. Right stabilizer spar tube. NTSB file 3-2273.
L8	Sikorsky S-55	23 Jul 68	0 D	Marathon, Ont. Canada. Bolts attaching the tail rotor pylon assembly (threads). Ref: MOT Canada file 3982.
L9	Bell 47J	1970	0 S	Cook SA, Australia. Stabilizer tube assembly at inboard end. Severe fretting at inner & outer tubes. Ref: Australia
L10	Hughes 269B	27 Sep 70	1 D	Ste. Pie de Bagot, Que. Canada. Tailboom left support strut lower fitting (fretting). Misalignment during rebuild after previous accident. Ref: MOT Canada file Q0074.

L-2

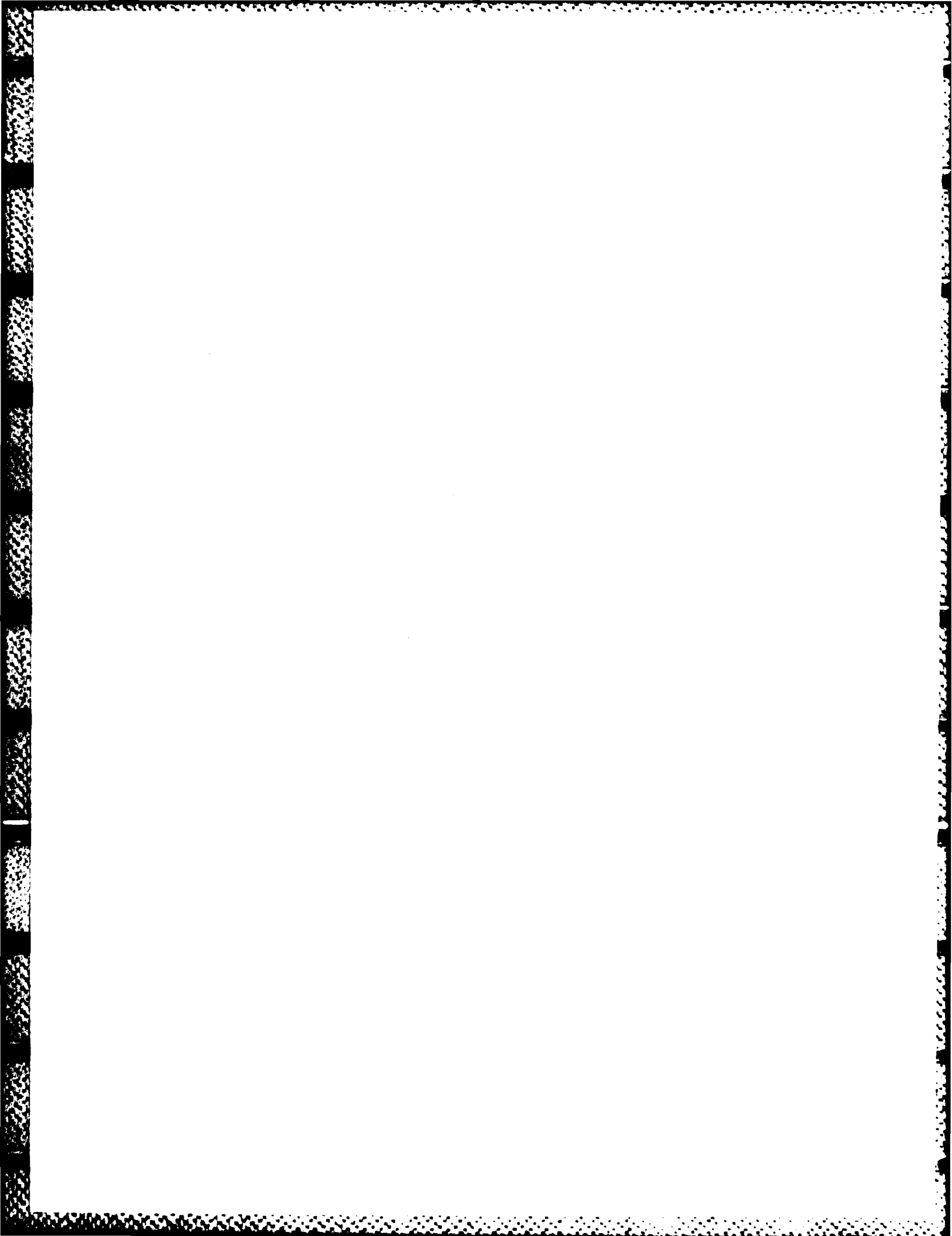
AIRFRAME (ROTARY-WING)

L11 Sikorsky S-58ET	25 Mar 72	0	S Darwin, Australia. Tail rotor assembly and gear box separated. Cracks in gear box mounting flange. Pylon fitting also had cracks. Ref: WHAS p. 10.
L12 Hughes 269B	11 May 72	0	S Saratoga, N.Y. USA. Tail boom attach strut. Ref: NTSB file 3-0749.
L13 Sikorsky S-55	19 Sep 73	0	S Duette, Fla. USA. Tail boom pylon ring. Ref: NTSB file 3-3903.
L14 Bell 47G-5	25 Oct 73	2	D Waynesburg, Pa. USA. Tail boom separated at STA 70, poor weld repairing previous damage. NTSB file 3-3225
L15 Sud Aviation SA 318C Alouette II	22 Jan 74	0	S Schaphusen, W. Germany. Stabilizer spar tube (prohibited weld repair). Ref: W. German file 3X0005.
L16 Hughes 269B	21 Feb 74	0	S Saitama Pref., Japan. Cluster fitting of centre frame. Crack origin: pitting corrosion. Ref: Japan MoT.
L17 Hughes 269B	27 May 74	0	S Las Vegas, Nev. USA. Horizontal stabilizer attachment. Ref: NTSB file 3-3804.
L18 Hiller FH-1100	24 Nov 74	1	D Freeport, NY USA. Aft tail boom separated, cracks in tail fin spar channel. Role: police patrol. Ref: NTSB file 3-4332
L19 Hughes 269B	27 Nov 74	0	D Omahaki Station, New Zealand. Attachment lug of port tailboom support strut. Ref: NZ brief 74-131.
L20 Sud Aviation SA 318B Alouette II	27 Feb 75	0	S Oberpleis, W. Germany. Tubular spar of stabilizer. Ref: W. German file 3X0023.
L21 Enstrom F-28A	5 Jul 75	0	S San Francisco, Cal. USA. Tail boom attach bolt. Ref: NTSB file 3-4031.
L22 Hughes 269B	15 Jul 75	0	D Niigata Pref., Japan. Stress concentration at fitting metal and rivet of horizontal stabilizer. Ref: Japan MoT
L23 Hughes 269C	17 Sep 75	0	D Rovaniemi Airport, Finland. Gear box to fuselage fastening strut broke, allowing rotor steering system to move freely. Ref: Finland BoA.
L24 Hughes 269A	14 Oct 75	0	S Wichita, Kans. USA. Tail boom end fitting (surface scratch). Ref: NTSB file 3-3467.

L-3
AIRFRAME (ROTARY-WING)

L25 Bell 205A-1	23 Apr 76	12	D	Gulf of Mexico near Louisiana USA. Tail boom/fuselage attach fittings. Ref: NTSB file 3-2324
L26 Bell 47K	22 May 76	0	D	Greenwich, R.I. USA. Right elevator tubular spar. Elevator struck tail rotor. NTSB file 3-0999
L27 Bell 204B	11 Feb 77	0	D	Shizuoka Pref., Japan. Fitting flange of vertical fin. Ref: Japan MoT
L28 Hughes 269B	30 May 77	0	S	Evart, Mich. USA. Tail boom center attach fitting. Ref: NTSB file 3-3150.
L29 Bell 214B-1	31 May 77	2	D	Liberty, Wash. USA. Separation of vertical fin. Ref: NTSB file 3-1607
L30 Sikorsky S-55	15 Aug 78	0	S	Carver, Ma. USA. Attach bolts of vertical pylon of tail boom. Ref: NTSB file 3-3733.
L31 Sikorsky S-55	6 Nov 78	0	S	Quesnel, B.C. Canada. Tail rotor pylon assembly. Fretting fatigue pre-cracking of assembly in area of tail cone ring. Ref: ICAO ADREP 2042/78
L32 Hughes 269C	15 Dec 79	1	D	West Milton, Ohio, USA. Tailboom centre attach fitting. NTSB file 3-3423
L33 Aerospatiale SA 315B Lama	5 Apr 81	0	S	Kawakawa Bay, New Zealand. Top right tailboom longeron at bushing attaching tailplane. Poor weld repairing previous damage. Ref: NZ brief 81-040.
L34 Hughes 269A	29 Aug 81	0	S	Campbell River, B.C. Canada. Tailboom separated at tailboom centre support fitting (rivet head fretting). Ref: MOT Canada file P10090.
L35 Bell 222	16 Apr 82	3	D	Hinton, Ok. USA. Main rotor blade control link. Ref: HELICOPTER INTERNATIONAL, Jul-Aug/82 pp 31-32.

Total Fatalities: 25



* APPENDIX M *
* ROTARY WING - FLIGHT CONTROLS *

ID No.	Aircraft Type	Accident Date	No. a Dead	D m	Remarks
M1	Cierva Air Horse	13 Jun 50	3	?	England. Carrier driving link of front rotor. Ref: THE AEROPLANE, July 5/50 p. 5
M2	Bell 47G-2	11 Jul 64	0	S	Wall, S.D. USA. Tail rotor pitch control system. NTSB file 2-0317
M3	Hiller UH-12E	7 Jul 65	0	D	Meeteetse, Wyo. USA. (Cyclic pitch control system). Bolt holding wobble plate pylon not properly secured, allowing plate to fail in fatigue. Role: aerial application. Ref: NTSB file 2-0491.
M4	Bensen B-8M Gyro-Copter	25 Sep 66	1	D	Benton, Pa. USA. Head fork assembly strap. NTSB file 2-0993
M5	Bell 47G-2	2 Dec 67	0	S	Lahabra, Cal. USA. Tail rotor pitch change link (improper installation). Tensile strength below manufacturer's requirements. Ref: NTSB file 2-1179.
M6	Sikorsky H-19G	1 Oct 68	0	S	Mandeville, La. USA. Tail rotor control rod bearing. Ref: NTSB file 3-4104
M7	Bell 47G-5	23 Nov 68	0	S	Rochester, Mass. USA. Failure of shaft to cylinder servo valve, cyclic pitch control system. Ref: NTSB file 3-4913.
M8	Bell 206A	15 Mar 69	0	D	Springfield, Ohio. USA. Right-hand cyclic bell-crank support. Ref: NTSB file 3-3060.
M9	Bell 206A	20 Jul 69	1	S	Mile 142 Alaska Highway, BC, Canada. Bearing connecting pitch link to swash-plate outer ring went out of position. Pitch link lower clevis contacted the swash plate horn, causing abnormal bending loads & fatigue failure of clevis. Ref: MoT Canada file 5002-4452.
M10	Fairchild Hiller FH-1100	21 Jul 69	1	?	Opapimiskan Lake, Ont. Canada. Swash-plate input push-rod assembly at rod-end retainer. Ref: MoT Canada.

M-2

FLIGHT CONTROLS (ROTARY-WING)

M11 Sikorsky S-64E	2 Sep 69	3	D Prudhoe Bay, Alaska USA. Tail-rotor pitch-control link assembly. Ref: NTSB file 3-3686
M12 Bell 47G	5 Mar 70	0	S Fort Worth, Tex. USA. Sheared delta hinge bolt caused failure of pitch control bearing & tail rotor separation. Ref: NTSB file 3-0548.
M13 Bell 47G-5	21 Jan 72	0	S Koloa, Hawaii. USA. Cyclic-pitch control boost cylinder. Ref: NTSB file 3-0283.
M14 Hiller FH-1100	30 Jun 74	5	D Umiat, Alaska USA. Swashplate assembly, cracks at two bolt holes. Ref: NTSB file 3-3039
M15 Bell 205A-1	21 Jul 74	0	D Umiat, Alaska USA. Tail rotor pitch-change chain. Ref: NTSB file 3-4266.
M16 Bell 47G-3B-1	5 Sep 74	1	D Ogden, Utah USA. Lost lateral cyclic control. Shaft separation due to off-centre drilled hole. Ref: NTSB file 3-3686
M17 Bell 47G-4A	10 Jan 76	0	S Encinal, Tex. USA. Tail rotor pitch change link. NTSB file 3-0079
M18 Hiller UH-12E	14 Mar 76	0	D Bluff, Ut. USA. (Cyclic pitch control system). Wobble plate pylon failed. Ref: NTSB file 3-0857.
M19 Hughes 269B	5 Feb 77	2	D Cascade Creek, New Zealand. Upper scissors link support of main rotor. Possible installation of wrong thrust bearing. Ref: NZ AAR 77-023
M20 Aerospatiale SA 318 Alouette II	16 Jun 77	0	S Hawkes Lake, Man. Canada. Tail rotor pitch change link. Ref: MoT Canada file C70080.
M21 Hiller 12EJ3	28 Jul 77	1	D Ketchikan, Alaska USA Cyclic pitch control system failed. Cyclic isolation-link hollow-shank rod-end bearing had same ID no. as correct solid rod end. Role: aerial survey. Ref: NTSB file 3-4203
M22 Kawasaki KH-4	9 Aug 77	0	D Ibaragi Pref., Japan. Origin: Pitting corrosion at support parts of torque tube assembly. Ref: Japan MoT.
M23 MBB BO 105	15 Dec 77	0	D Kassel, W. Germany. Tail-rotor pitch control linkage, rotor control shaft fitting. Ref: W. German file 3X0569.

FLIGHT CONTROLS (ROTARY-WING)

M24 Bell 47G-5	1978	0	S Winton, Qld. Australia. Tail rotor pitch-change rod. Role: cattle mustering. Ref: Australia DoT.
M25 Hiller UH12E	19 May 78	0	S Karamea, New Zealand. Left tail rotor control cable near pulley. Ref: NZ brief 78-075.
M26 Bell 47G-4	12 Jun 78	0	S Bremm A.D. Mosel, W. Germany. Tail rotor pitch control system. Ref: W. German file 3X0188.
M27 Westland 47G-3	11 Jul 78	0	D Wintringen, W. Germany. Tail rotor pitch control system (steering cable). Ref: W. German file 4X0034.
M28 Bell 205A-1	18 Aug 78	1	D Dennison Mines, BC, Canada. Tail-rotor pitch-change chain. Ref: MoT Canada file P80085
M29 Hiller UH-12J	20 Nov 78	0	S Between Arawhata & Waitoto Rivers, New Zealand. Main rotor control "paddles" separated. Origin: fretting at inboard bolt holes by trunnion bearing cuffs. Ref: NZ brief 78-151.
M30 Agusta 47J-3	11 Jun 79	0	S Iphofen, W. Germany. Tail rotor pitch control system. Ref: W. German file 3X0207.
M31 Bell 47G-3B KH-4	11 Jun 80	0	D Ibaragi Pref., Japan. Fitting bolt of forward & aft cyclic control rod. Ref: Japan MoT.
M32 Bell 47G-2A	3 Sep 80	2	D Cottonport, La. USA. Lateral control torque tube pivot shaft of cyclic pitch control system. NTSB file 3-2504.
M33 Bell AH-1S HueyCobra (US Army)	23 Mar 81	0	D Germany. Failure of tube assembly. Ref: US Army.
M34 Aerospatial AS 350D Astar	4 May 81	0	S Gulf of Mexico. Tail rotor pitch horn. Ref: NTSB file 3-1183.
M35 Westland 47G-3B-1	4 Jul 81	0	S Koldingen, W. Germany. Main rotor cyclic pitch control. Damper shaft in region of clamp. Ref: W. German file 3X0304.
M36 Bell 212	11 Sep 81	0	S Wadlin Lake, Alta. Canada. "White" tail rotor pitch link. Premature wear of rod end bearing produced abnormal loading & fatigue initiation. Ref: MoT Canada file W10113

FLIGHT CONTROLS (ROTARY-WING)

Left tail rotor control cable fractured (improper rigging). Ref: ICAO ADREP 131/82.

Total Fatalities: 34

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ENGINE/TRANSMISSION (ROTARY-WING)

* APPENDIX N *
* ROTARY-WING - ENGINE OR TRANSMISSION *

ID No.	Aircraft Type	Accident Date	No. a Dead	D m	Remarks
N1	Bell 47D-1	15 Sep 50	0	S	Liege, Belgium. Blade of engine cooling fan. Ref: Belgium AA.
N2	Hiller 360	7 Feb 52	1	D	Toussus-le-Noble, France. Connecting rod in no. 2 cylinder. Ref: ICAO AAD No. 3 1953, p. 122
N3	Sikorsky S-58D	11 Jul 63	0	S	Larchwood, Ont. Canada. Threaded end of knuckle pin retaining bolt. Ref: MoT Canada file 2020.
N4	Bell 47G	14 Oct 63	0	S	Porcupine River, Que. Canada. Connecting rod bolts at thread. Ref: MoT Canada file 2138.
N5	Boeing Vertol 107-II (New York Airways)	14 Oct 63	6	D	Jamaica, N.Y USA. Quill drive shaft (contamination of lubrication system in aft transmission assembly). Ref: ICAO AAD No. 15, Vol. I, 1966, p. 116.
N6	Sikorsky S-55	4 Aug 64	0	S	Esker, Lab. Canada. No. 8 cylinder exhaust valve housing at rocker shaft small bushing boss. Ref: MoT Canada file 2336.
N7	Bell 47G	27 Sep 64	0	S	Bakersfield, Cal. USA. Exhaust rocker arm bolt, no. 3 cylinder. Ref: NTSB file 2-0779.
N8	Bell 47J-2	22 Dec 64	0	S	Philadelphia, Pa. USA. No. 1 cylinder connecting rod. NTSB file 2-0943.
N9	Hiller 360	6 Apr 65	0	S	Ludham, UK. No. 4 piston. Ref: UK BoT C.A.P. 265 p 49.
N10	Hughes 269A	21 Apr 65	0	D	Columbus, Ohio USA. Engine flywheel weight assembly. Ref: NTSB file 2-0858.
N11	Brantly B-2B	25 Sep 65	0	S	Denver, Colo. USA. Connecting rod cap bolt. Ref: NTSB file 2-0921.
N12	Hughes 269B	25 Feb 66	0	S	May Pen, Jamaica. Fuel feed pipe-line to No. 3 cylinder. Ref: Jamaica.

N-2

ENGINE/TRANSMISSION (ROTARY-WING)

N13 Bell 47D-1	12 Mar 66	0	S	Shelby, Miss. USA. No. 2 connecting rod. Ref: NTSB file 2-0324.
N14 Sikorsky S-55	22 Jun 66	0	S	Prince George, B.C. Canada. No. 1 cylinder exhaust rocker box casting. Ref: MoT Canada file 2985.
N15 Bell 47G-3B-1	16 Aug 66	0	S	Telegraph Creek, B.C. Canada. Fan blade (improper installation). Ref: MoT Canada file 3090.
N16 Hiller UH-12E	24 Aug 66	0	S	Rainbow Lake, Alta. Canada. No. 1 connecting rod (inadequate torquing). Ref: MoT Canada file 3101.
N17 Hiller UH-12E	11 Sep 66	0	S	Happy Camp, Cal. USA. No. 4 cylinder connecting rod bolt. Ref: NTSB file 2-1184.
N18 Bell 47J-2	26 Oct 66	0	S	Brookline, Mass. USA. Teeth in fan drive gears. Ref: NTSB file 2-1189
N19 Bell 47G-3B	4 Jan 67	0	S	Glenwood Springs, Colo. USA. Piston pin, no. 6 cylinder. NTSB file 2-0065.
N20 Hughes 269B	4 Feb 67	0	S	Culver City, Cal. USA. Attach fitting of clutch actuator electro-mechanical unit. No lubrication on pin or fitting. Ref: NTSB file 2-0632.
N21 Hughes 269B	13 May 67	0	S	Saluda, S.C. USA. Malfunction of main rotor gear drive assembly due to failure of huck bolts. NTSB file 2-0807.
N22 Hughes 269B	30 May 67	0	S	Lakewood, Cal. USA. Improper con rod bolts in no. 4 cylinder failed Ref: NTSB file 2-0656.
N23 Hughes 269A	12 Oct 67	0	S	Lula, Miss. USA. Lower coupling drive shaft. NTSB file 2-0930.
N24 Fairchild Hiller FH-1100	8 Jun 68	0	S	Fort Nelson, B.C. Canada. Forward diaphragm of centre disc on front end diaphragm pack of power transmission shaft. Ref: MoT Canada file 3915.
N25 Bell 47G-3B-1	24 Jun 68	0	S	Fuller Lake, Y.T. Canada. Wrist pin of piston, no. 1 cylinder. Ref: MoT Canada file 3944.
N26 Bell 206A	31 Aug 68	0	S	Medfra, Alas. USA. First stage compressor vanes. NTSB file 3-4899.
N27 Brantly B-2	30 Mar 69	0	D	Aberdeen, Md. USA. No. 4 piston connecting-rod attach bolt. Ref: NTSB file 3-0954.

N-3
ENGINE/TRANSMISSION (ROTARY-WING)

N28 Hiller FH-1100	11 Jun 69	3	D Niwelin Lake, NWT, Canada. Bendix engine-to-transmission driveshaft. Ref: MoT Canada file 5002-4412.
N29 Hiller UH-12E	9 Jul 69	0	S Bettles, Alas. USA. No. 5 cylinder con rod cap and bolts. Ref: NTSB file 3-3527.
N30 Bell 47G-3B-1	23 Jul 69	0	S Stirling City, Cal. USA. External supercharger (turbine wheel). Ref: NTSB file 3-3595.
N31 Hughes 269B	17 Aug 69	0	D Lakewood, Calif. USA. Failure of electro-mechanical actuator in transmission rotor drive system created disconnect of power drive pulley belts to engine. Ref: NTSB file 3-2563.
N32 Hughes 269B	17 Mar 70	0	S Santa Monica, Cal. USA. No. 4 cylinder connecting rod. NTSB file 3-4483.
N33 Bell 47J-2	22 Apr 70	0	S Piscataway, N.J. USA. Free wheeling gear in main rotor drive system. Ref: NTSB file 3-0343.
N34 Bell 206A	25 Apr 70	0	S Morgan City, La. USA. Blade of 2nd stage gas producer turbine wheel. Ref: NTSB file 3-1457.
N35 Bell 206A	21 May 70	0	S Pennsauken, N.J. USA. Two 5th stage compressor blades. Ref: NTSB file 3-4596.
N36 Bell 206A	19 Jan 71	0	S Lac Duprat, Que. Canada. Compressor rotor assembly's 3rd stage com- pressor blades (abnormal vibrations). Ref: MoT Canada file Q1002.
N37 Bell 206A	9 Jun 71	0	D Gulf of Mexico off Louisiana, USA. 2nd phase turbine wheel. Ref: NTSB file 3-2158
N38 Bell 47G-4-A	10 Sep 71	0	S Shelbyville, Ky. USA. Bolt to # 6 con rod. Ref: NTSB file 3-3249.
N39 Hughes 269C	3 Dec 71	0	S Hallandale, Fla. USA. # 1 exhaust valve. Ref: NTSB file 3-3273.
N40 Hiller 360-UH	28 Feb 72	2	D England. Failure of a planet gear in the first-stage reduction housing, causing main rotor to detach. Ref: UK AIB CAAR 13/73.
N41 Bell AH-1G HueyCobra (US Army)	1 Mar 72	0	S Vn. USA. Engine (compressor blade). Ref: US Army

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ENGINE/TRANSMISSION (ROTARY-WING)

N42 Hughes OH-6A Cayuse (US Army)	15 May 72	0 D?	Vn. USA. Engine failure (band & vane assembly). Ref: US Army
N43 Hiller UH-12E	7 Jul 72	0 S	Umiat, Alas. USA. # 3 conrod and cap (fretting). NTSB file 3-1256
N44 Hiller FH-1100	19 Jul 72	0 S	North Bend, Wash. USA. 1 blade from each stage of 5th & 6th compressor wheel. Ref: NTSB file 3-3269.
N45 Bell 206A	2 Aug 72	0 S	Rocky Hill, Conn. USA. Compressor blade (overhaul overdue). Ref: NTSB file 3-1806.
N46 Aerospatiale Alouette III	8 Aug 72	0 S	Greybull, Wy. USA. Main drive shaft (faulty machining). Ref: NTSB file 3-1246.
N47 Hughes OH-6A Cayuse (US Army)	17 Sep 72	0 S	Vn. USA. Engine failure (compressor rotor). Ref: US Army
N48 Hughes 269C	19 Oct 72	0 S	Chamblee, Ga. USA. # 4 connecting rod bolt. Origin: surface damage. Ref: NTSB file 3-0854
N49 Bell 47G-3B-1	9 Nov 72	3 D	Piz Muttler, Switzerland. Cooling fan blade (fretting at bolt). Ref: Switzerland Accident Report 1972/82 837.
N50 Bell UH-1B (US Army)	18 Jan 73	0 S	Al. USA. Engine power shaft. Ref: US Army.
N51 Westland Whirlwind S-55	28 Feb 73	4 D	Eket, Nigeria. Failure in transmission/rotor drive main gearbox. Ref: ICAO ADREP 265/73
N52 Hughes 369HS	28 Mar 73	0 S	Point La Hache, La. USA. Compressor, spur adapter gear shaft. Ref: NTSB file 3-0838.
N53 Bell OH-58A Kiowa (US Army)	29 Mar 73	0 S	N.C. USA. Engine compressor rotor. Ref: US Army.
N54 Bell 47G-4A	5 Apr 73	0 S	Washington, D.C. USA. No. 6 cylinder conrod cap bolt. NTSB file 3-1877
N55 Hughes 269C	2 Oct 73	2 D	Oakland, Calif. USA. Main-rotor gear drive-shaft failed, main rotor separated. Ref: NTSB file 3-3942
N56 Hughes 269B	16 Oct 73	2 D	Springfield, Ohio USA. Lower-coupling drive shaft, tail-rotor drive-shaft assembly. Ref: NTSB file 3-3968

N-5
ENGINE/TRANSMISSION (ROTARY-WING)

N57 Hughes 369H	1974	0	D Derby W.A., Australia. Out-of-balance blade due to loss of abrasion tape caused gearbox separation (fatigue) at flange. Ref: Australia DoT.
N58 Bell 47G-3B-2	1974	0	S Mt. Bundy Stn. Australia. Connecting rod bearing. Origin: galling on bearing borecon rod. Ref: Australia DoT.
N59 Hiller UH-12E	2 Feb 74	0	S National Park, New Zealand. No. 6 cylinder con-rod bolt. NZ brief 74-016.
N60 Hughes 369HS	2 Apr 74	0	S Petersburg, Alas. USA. 1st stage turbine wheel (thermal fatigue). Ref: NTSB file 3-3343.
N61 Bell OH-58A Kiowa (US Army)	9 Apr 74	0	S Germany. Engine compressor rotor. Ref: US Army.
N62 Bell OH-58A Kiowa (US Army)	10 Sep 74	0	S Ky. USA. Compressor rotor. Ref: US Army.
N63 Boeing Vertol CH 147 Chinook (Canadian Forces)	18 Oct 74	5	D Middletown, Pa. USA. Combining transmission spiral bevel gear. Origin: non-metallic inclusion on gear flange. Ref: CF ACAIRS.
N64 Bell UH-1H Iroquois (US Army)	23 Oct 74	0	S Tn. USA. Engine (blade). Ref: US Army.
N65 Enstrom F-28A	1975	0	S Curlew Waterhole, Australia. RH front transmission bolt failed, resulting in failure of collective pitch control bellcrank. Ref: Australia DoT.
N66 Hughes 269B	19 Mar 75	0	S Gail, Tex. USA. No. 4 conrod. Ref: NTSB file 3-2621.
N67 Boeing Vertol CH-47C Chinook (US Army)	13 Jun 75	0	D Germany. Blade in engine. Ref: US Army.
N68 Bell 206A	30 Jul 75	0	S Barter Island, Ak. USA. 5th stage compressor wheel blades. Ref: NTSB file 3-4016.
N69 Brantly B-305	29 Sep 75	0	D Budir, Faskruds fjordur, Iceland. Piston rod. Engine far above authorized lifetime. Ref: Iceland.
N70 Sikorsky Sea King 50 (RAN)	21 Oct 75	0	D At sea off Nowra, Australia. Transmission oil filter retaining bolt. Ref: Royal Australian Navy.

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ENGINE/TRANSMISSION (ROTARY-WING)

N71 Bell 47J-2	22 Oct 75	0	S	Conshocken, Pa. USA. No. 5 connecting rod. Ref: NTSB file 3-3781.
N72 Bell UH-1H Iroquois (US Army)	30 Oct 75	3	D	Al. USA. Engine (turbine rotor). Ref: US Army.
N73 Hughes 500	12 Jan 76	0	S	Mildred Lake, Alta. Canada. Compressor. Ref: MoT Canada file W60002.
N74 Hughes 369HS	26 Jan 76	0	S	Yokohama, Japan. 3rd stage compressor blade. Origin: pitting corrosion. Ref: Japan MoT
N75 Fairchild FH-1100	2 Jul 76	3	D	Porter Lake, NWT, Canada. Transmission, main-rotor drive-shaft (Bendix coupling). Ref: MoT Canada file W60057
N76 Bell 206	21 Jul 76	0	S	Eastmain, Que. Canada. Engine air pressure line at flared end in pressure sleeve. Ref: MoT Canada file Q60086.
N77 Hughes 269C	2 Aug 76	0	D	Miyagi Pref., Japan. Stress concentration, exhaust valve of #2 cyl. Ref: Japan MoT.
N78 Hughes 369HS	5 Sep 76	0	S	Hornu, Belgium. 4th stage compressor blade. Ref: Belgium AA.
N79 Aerospatiale SA 316 Alouette III	5 Sep 76	0	S	Grassy Narrows, Ont. Canada. Fuel injection wheel of fuel system. Ref: MoT Canada file C60150
N80 Sikorsky Sea King 50 (RAN)	2 Dec 76	0	D	At sea off Nowra, Australia. Transmission oil filter retaining bolt. Ref: Royal Australian Navy.
N81 Bell 206L LongRanger	17 Dec 76	0	D	Anchorage, Alaska USA. Failure of turbine blade, turbine wheel. Ref: NTSB file 3-4160.
N82 Enstrom F-28A	13 Jan 77	0	S	Boynton Beach, Fla. USA. Transmission rotor drive system: clutch assembly, idler yoke. Ref: NTSB file 3-4269.
N83 Bell 214B-1	30 May 77	0	S	Clover Bar, Alta. Canada. Engine accessory drive inner bevel gear. Ref: MoT Canada file W70056.
N84 MBB BO 105	7 Jun 77	0	S	Intracoastal City, La. USA. Right engine fourth stage turbine wheel. Corroded & fatigue fracture. ICAO ADREP 222/77.
N85 Bell 47G-4A	8 Jun 77	0	D	Boitzenhagen, W. Germany. Connecting rod big-end bearing. Ref: W. German file 3X0199

ENGINE/TRANSMISSION (ROTARY-WING)

N86 Hiller 12	15 Jun 77	0	S	Lemory, B.C. Canada. Crankshaft. MoT Canada file P70038.
N87 Aerospatiale SA 316B Alouette III	21 Jun 77	0	D	Tokushima Pref., Japan. Stress concentration at flange on coupling shaft of engine. Ref: Japan MoT.
N88 Westland Wessex 31B (RAN)	13 Jul 77	0	D	At sea, HMAS Melbourne. Engine compressor blades. Ref: Royal Australian Navy.
N89 Bell 214B1	30 Jul 77	0	S	Sawyers Bar, Cal. USA. Accessory inner bevel gear. NTSB file 3-3960.
N90 Hughes 269C	22 Aug 77	0	D	Yamagata Pref., Japan. Pitting corrosion at 3rd stage compressor blade Ref: Japan MoT
N91 Sikorsky S-58	30 Sep 77	1	S	Garmisch-Partenk, W. Germany. Carburetor: mixture-control pressure-diaphragm. Ref: W. German file 3X0515.
N92 Bell 47G-3B-1	2 Oct 77	0	S	Alsea, Ore. USA. Transmission rotor drive system: bogus part in clutch assembly. Central hub separated from centrifugal clutch drum. Web below thickness requirement. NTSB file 3-3593.
N93 Hughes 269B	1 Dec 77	0	S	Speedway, Ind. USA. Main rotor gear box ring gear drive coupling. Ref: NTSB file 3-4275.
N94 Hiller FH-1100	22 Dec 77	0	D	Walton, Oregon USA. Left transmission lift link strut. Role: aerial logging. Ref: NTSB file 3-4116.
N95 Bell 206B	1978	0	D	Queensland Australia. Drive shaft between engine & rotor gear box. Ref: Australia DoT.
N96 Westland Wessex 31B (RAN)	22 Jan 78	0	S	At sea, off Nowra, Australia. Drive shaft of engine-driven fuel pump. Ref: Royal Australian Navy.
N97 Bell 47G	6 Mar 78	0	S	New Bern, N.C. USA. Crankshaft (no. 1 conrod journal). Ref: NTSB file 3-1082.
N98 Bell 206B	9 Apr 78	0	S	East Meadow, N.Y. USA. Fuel pump drive splines. Ref: NTSB file 3-2171.
N99 Aerospatiale SA 330J Puma	7 May 78	2	S	Atlantic City, N.J. USA. Engine drive shaft failed, main rotor separated. Ref: NTSB file 3-2494

N-8

ENGINE/TRANSMISSION (ROTARY-WING)

N100	Bell UH-1M Iroquois (US Army)	19 Oct 78	0	S	Pa. USA. Engine (gear assembly). Ref: US Army.
N101	Bell AH-1G HueyCobra (US Army)	31 Oct 78	0	D	Al. USA. Engine (pin). Ref: US Army.
N102	Bell 47G-4A	8 Nov 78	0	S	Hokkaido, Japan. # 2 connecting rod. Origin: pitting corrosion. Ref: Japan MoT.
N103	Hiller UH-12 Soloy	22 Dec 78	0	S	Lacomb, Ore. USA. Tachometer generator. NTSB file 3-4115.
N104	Bell 47	1979	0	D	Timber Creek, Australia. Turbo wastegate seal. Ref: Australia DoT
N105	Hiller UH-12	1979	2	D	Dorisvale, NT Australia. Studs connecting torsion coupling to upper coupling. Ref: Australia DoT.
N106	Boeing Vertol 14 CH-47C Chinook (US Army)	14 Mar 79	0	D?	S. Korea. Bevel gear in combining transmission. Ref: US Army
N107	Aerospatiale SA 360C Dauphin	20 Mar 79	0	S	Fukushima Pref., Japan. Flared part of fuel tube. Ref: Japan MoT.
N108	Bell 206B	3 Jun 79	0	D	Morgan City, La. USA. Turbine blade. NTSB file 3-2100.
N109	Fairchild FH-1100	25 Jul 79	0	S	Riviere Eternite, Que. Canada. Abraidable plastic compressor case liner was severely eroded on one side. Disturbed airflow. Fourth stage compressor blade failed. Ref: MoT Canada file Q90080.
N110	Kaman HH-43F	24 Aug 79	0	D	Hamilton, Mt. USA. Fracture of engine drive shaft (powershaft) in area of heavy wear. Ref: NTSB file 3-4011.
N111	Bell 206B	11 Sep 79	0	S	Merrimack, N.H. USA. PC line at fuel control. NTSB file 3-3170.
N112	Hughes 269	1980	0	S	Grove Hill, Australia. Lower pulley coupling shaft in transmission rotor drive system. Ref: Australia DoT.
N113	Bell OH-58A Kiowa (US Army)	10 Jan 80	0	D?	Germany. Engine gear assembly. Ref: US Army.
N114	Aerospatiale AS 350 Astar	26 Jan 80	1	S	Heaven Lake, Ont. Canada Axial-stage blade of engine. Ref: MoT Canada file 80-C00006.

N-9
ENGINE/TRANSMISSION (ROTARY-WING)

N115 Hughes 269C	4 Apr 80	0	D Te Anga, Te Kuiti, New Zealand. Main rotor ring gear drive shaft. Fretting near lockpin holes. Ref: NZ brief 80-048.
N116 Bell 206L-1 LongRanger	6 May 80	2	D Gibson, La. USA. #4 bearing failed in reduction gear assembly. Ref: NTSB file 3-2939.
N117 Boeing Vertol CH-47C Chinook (US Army)	4 Jun 80	0	S S. Korea. #1 engine exploded (gear assembly failure). Ref: US Army.
N118 Bell 206A	13 Jun 80	0	D McKinley Bay, NWT Canada. 1st stage gas producer turbine wheel. Thermal fatigue precrack in outer rim of wheel. Ref: MoT Canada file 80-W00052.
N119 Hiller 12	5 Jul 80	0	S Lockwood Lake, Sask. Canada. No. 1 connecting rod. Origin: galled area on bore of rod at crankshaft end. Ref: MoT Canada file C00082.
N120 Hughes 269B	12 Jul 80	0	S Washington, D.C. USA. Fatigue fracture of #5 hold down stud on #3 cylinder. Corrosion. Ref: NTSB file 3-2181.
N121 Hughes 500	25 Jul 80	0	S Falcon Lake, Man. Canada. Tooth on output drive bevel gear in main rotor drive assembly. Coarse machining marks in root fillet of teeth. Ref: MoT Canada file C00091.
N122 Aerospatiale SA 360C Dauphin	21 Sep 80	0	S Kagoshima Pref., Japan. Input flange of main gear box. Ref: Japan.
N123 Hughes 269C	31 Oct 80	0	D 170 nm north of Ostersund, Sweden. Transmission drive shaft broke 9 cm from end. Torsional fatigue. Subsurface initiation. Ref: Sweden Board of Civil Aviation
N124 Bell 206B	31 Dec 80	0	S Patterson, La. USA. 2nd stage turbine wheel blade. NTSB file 3-3691
N125 Hughes 269C	10 Jan 81	0	D Viper, Ky. USA. Lower coupling drive shaft. NTSB file 3-0313.
N126 Bell 206B	22 Feb 81	0	S Niigata Pref., Japan. 3rd stage blade. Ref: Japan MoT.
N127 Bell 206L-1 LongRanger	25 Mar 81	0	S Gulf of Mexico, USA. Compressor, spline adapter. NTSB file 3-1400.
N128 Aerospatial AS 350D Astar	11 Apr 81	0	S Edmond, Ok. USA. Bendix fuel control speeder spring. Ref: NTSB file 3-0990.

N-10

ENGINE/TRANSMISSION (ROTARY-WING)

N129 Sikorsky S-61L Mark I	15 Apr 81	0	D Cape Town, South Africa. Spur gear in main rotor gearbox. Ref: South Africa DoT; ICAO ADREP 108/81.
N130 Bell 206L-1 LongRanger	25 Apr 81	0	S Leeville, La. USA. Turbine nozzle. Ref: NTSB file 3-2527.
N131 Bell 47G-4A	28 Apr 81	0	S Birds Hill, Man. Canada. Camshaft gear attachment bolts, improper assembly. Ref: MoT Canada file C10031.
N132 Bell 47A-J2	29 Apr 81	0	S Whitehorse, Y.T. Canada. Engine cooling fan assembly mounting studs. Ref: MoT Canada file W10031.
N133 Hughes 269C	4 May 81	0	S Washington, D.C. USA. Main rotor shaft ring gear carrier. Ref: NTSB file 3-1426.
N134 Bell 47J-2	26 May 81	0	S Branson, Mo. USA. #6 con rod. Ref: NTSB file 3-1089.
N135 Sikorsky S-64 Skycrane	5 Jun 81	1	S Kitsault River, B.C. Canada. No. 1 engine, 6th stage compressor disc. Ref: MoT Canada file P10902.
N136 Hughes 500	24 Aug 81	1	D Philomena, Alta. Canada. Transmission input pinion (corrosion pit). Ref: MoT Canada file W10103.

Total Fatalities: 44

* APPENDIX O *
* ROTARY-WING - LANDING GEAR *

ID No.	Aircraft Type	Accident Date	No. a Dead	D m	Remarks
01	Sikorsky S-61	15 Jul 63	0	S	Los Angeles, Ca. USA. Right main gear failed. Forged fittings. Origin: sharp corner on inside surface on closed end of tubular section. Ref: WHAS p. 3.
02	Sikorsky S-61L (L.A. Airways)	15 Mar 66	0	S	Los Angeles, Cal. USA. Right landing gear brace fitting. Ref: NTSB file 1-0017.
03	Bell 204B	4 Apr 68	0	S	Kenai, Alas. USA. Rear float cross tube. NTSB file 3-2083.
04	Bell 47G-2	11 May 69	0	S	Lindenhurst, N.Y. USA. Skid assembly. Ref: NTSB file 3-1834.
05	Hughes 269A	31 Jul 74	0	D	W. Memphis, Ark. USA. Landing gear strut assembly. Ref: NTSB file 3-2129.
06	Bell TH-1G Iroquois (US Army)	16 May 75	0	S	Tx. USA. Left forward & aft cross tubes failed above the skid saddles. Ref: US Army.
07	Bell 204B	6 Feb 77	0	S	Sonderstromfjord, Greenland. Landing gear floats, right hand side of rear cross tube. Ref: ICAO ADREP 43/77.
08	Sikorsky S-61L (N.Y. Airways)	16 May 77	5	S	Pan Am building, New York, USA. Upper-right forward fitting of right main landing gear tube assembly. Matl: 7075-T73. Ref: NTSB file 1-0025
09	Hughes 269C	1978	0	S	Surfers Paradise, Australia. Cracks in both skid gear & left forward shock strut. Ref: Australia DoT.
010	Bell 205A-1 (on floats)	18 Jul 80	1	D	Arcola-Houston airport, Texas USA. Front cross tube of pontoon. Crack on right-forward cross tube where support saddle was riveted. Ref: NTSB file 3-3263.
011	Bensen B-8M	28 Sep 80	0	S	St. Joseph, Il. USA. Support bar for main landing gear. Ref: NTSB file 3-2454.

Total Fatalities: 6

* APPENDIX P *
* ROTARY-WING - MISCELLANEOUS *

ID No.	Aircraft Type	Accident Date	No. a Dead	D m	Remarks
P1	Bell 47D-1	30 Oct 51	1	S	Burk's Falls, Ont. Canada. Tail-rotor gear-box pinion shaft. Ref: ICAO AAD No. 3, 1953, p. 77
P2	Hiller UH-12E	23 Apr 63	0	S	Shalalth, B.C. Canada. Tail rotor pinion gear. Ref: MOT Canada file 1951.
P3	Bell 47D-1	3 Jul 64	0	D	Harlingten, Texas USA. Fracture of tail rotor drive shaft assembly. Role: aerial application. NTSB file 2-0249.
P4	Bell 47G-2	6 Mar 65	0	S	Barney's River Station, N.S. Canada. Tail rotor drive shaft (existing crack - probably from overload). Ref: MOT Canada file 2486.
P5	Brantly 305	18 May 66	0	S	Annapolis, Md. USA. Right oil cooling fan shaft. NTSB file 2-0422.
P6	Bell 204B	28 May 66	1	D	Lincoln Sea, Canada. Radio antenna tube (attached to vertical stabilizer) failed from fatigue & struck tail rotor. Origin: rivet hole. Ref: MoT Canada Ser. No. 2940
P7	Brantly B-2B	3 Mar 67	0	S	Cedar Rapids, Iowa. USA. Tail rotor drive shaft assembly. NTSB file 2-0260
P8	Sikorsky S-51	29 Aug 67	0	S	Windsor Locks, Conn. USA. Tail rotor drive shaft assembly (drive shaft rivets sheared). Ref: NTSB file 2-0633
P9	Westland Whirlwind HC.12 (Queen's Flight, RAF)	7 Dec 67	4	D	England. Main rotor shaft. Crack at rotor-head end of drive shaft, inside the main-rotor gearbox. Ref: FI 1 Feb. 68 p. 143, & 21 Dec. 67 p 1018.
P10	Hiller 12B	27 May 68	0	S	Arroyo Grande, Cal. USA. Tail rotor drive shaft assembly (centering pin of cardan joint). NTSB file 3-2188.
P11	Bell 47G-3B-1	25 Jun 68	0	S	Boron, Cal. USA. Tail rotor drive shaft assembly (improperly installed roller bearing). NTSB file 3-2096.

MISCELLANEOUS (ROTARY-WING)

P12 Bell 47G-3B-1	25 Jul 69	0	S	Fresno, Cal. USA. Tail rotor drive shaft assembly. NTSB file 3-3249
P13 Kawasaki/ Boeing KV-107 (Japanese Self-Defence Force)	1971	?	?	Japan. Failure of thrust deck, connecting the power- drive system to the fuselage, causing rear rotor to separate. Ref: FI 9 Mar. 72 p 368, & 13 Jan. 72 p. 74.
P14 Bell 47G-2A-1	10 Aug 71	2	D	Bellwood, Ill. USA. Tail rotor drive shaft yoke. Role: police patrol. Ref: NTSB file 3-4198
P15 Bell TH-13T (US Army)	6 Mar 72	0	D?	Al. USA. Tail rotor driveshaft assembly. Ref: US Army.
P16 S.N.I.A.S. SE 3160	21 May 72	0	S	Mayer, Ariz. USA. Clutch coupling bolts in universal joint. Ref: NTSB file 3-3954.
P17 Sikorsky S-55B	18 Jul 72	0	D	Benicia, Calif. USA. Front transmission support bracket failed. Over-sized engine installed. NTSB file 3-2519.
P18 Brantly B-2B	9 Nov 72	1	D	Oxford, England. Outboard pylon bearing shaft of main rotor blade. Ref: UK AIB CAAR 12/73.
P19 Bell 206B	19 Feb 73	5	D	Morgan City, La. USA. Pylon support link failed, causing complete failure of main rotor/transmission assembly. Ref: NTSB file 3-0135
P20 Bell 206B	22 Feb 73	1	D	Amelia, La. USA. Right pylon support link failed, causing in-flight failure of main rotor system. Ref: NTSB file 3-0425.
P21 Sud Aviation SA 318C Alouette II	2 Jun 73	0	D	Oberhoeffstadt, W. Germany. Tail rotor separated, fracture of tail rotor shaft. Ref: W. German file 3X0149
P22 Brantly B-2	21 Nov 73	0	D	North Bergen, N.J. USA. Vertical drive of tail rotor drive shaft assembly at bolt holes 1 inch from upper end of shaft. Ref: NTSB file 3-3668.
P23 Bell UH-1H Iroquois (US Army)	19 Jun 74	0	S	S.C. USA. Connector failed, causing yaw. Ref: US Army.
P24 Sud Aviation SA 341G	15 Feb 75	0	S	San Jose, Cal. USA. Tail rotor failure. Transmission cowling rubbed against tail rotor incline shaft, eventually fatigue-failing shaft. Ref: NTSB file 3-0315.

MISCELLANEOUS (ROTARY-WING)

P25 Agusta 47G-4 18 Feb 75 0 S Serringhausen, W. Germany.
Tail rotor driveshaft. Ref: W. German file
3X0022.

P26 Hughes 269C 26 Jul 75 0 S Enschede, W. Germany.
Bearing cage of main rotor clutch. Ref: W.
German file 3X0319.

P27 Sikorsky 3 Oct 75 0 D 30 km from Reykjavik, Iceland.
S-62A
Driving gear of intermediate gear box failed
(fatigue), causing tail rotor failure. A
slipping bearing race contributed. Ref: Iceland

P28 Bell 47G-3B 12 May 76 0 S Forks, Wash. USA.
Tail rotor gear box, pinion shaft. Tail rotor
separated. Ref: NTSB file 3-1227.

P29 Boeing-Vertol 16 May 76 4 ? Mediterranean Sea off carrier USS
H-46 Sea Knight
Guadalcanal. Crack in main rotor shaft.
(US Navy or
Ref: FI 26 June 76 p. 1699.
US Marines)

P30 Brantly 305 1 Oct 76 0 D Astley Village, England.
Main rotor gearbox, forward attachment bolt
(corrosion pit). Ref: UK Accident Report 5/78.

P31 Boeing Vertol 15 Jul 77 1 D Germany.
CH-47C Chinook
Main rotor shaft. Ref: US Army.
(US Army)

P32 Enstrom 7 Feb 78 0 S Waverley, New Zealand.
F-28C
Tail rotor drive shaft. Fatigue strength reduced
by softened condition & surface decarbur-
isation. AISI 4130 steel. Ref: NZ brief 78-018.

P33 Enstrom 17 Feb 78 0 S Centre Hill, New Zealand.
F-28A
Tail rotor drive shaft. Fatigue strength reduced
by softened condition & surface decarbur-
isation. Ref: NZ brief 78-026

P34 Bell OH-58A 1 May 78 0 S Wa. USA.
Kiowa
Power loss (tube assembly failure). Ref: US
(US Army) Army.

P35 Aerospatial 14 Dec 78 0 S Morgan City, La. USA.
AS 350C
Tail rotor failure. Fatigue fracture of gear in
accessory drive assembly. Ref: NTSB file 3-4335.

P36 Sikorsky 23 May 79 0 D At sea off HMAS Melbourne.
Sea King 50
Tail rotor drive shaft. Ref: Royal Australian
(RAN) Navy.

P37 Hughes 500 8 Oct 79 0 S Jenpeg, Man. Canada.
Tail rotor drive flexible coupling. Ref: MoT
Canada file C90124.

P-4

MISCELLANEOUS (ROTARY-WING)

P38 Hughes 369D	18 Oct 79	0	D Trenton, N.J. USA. Tail rotor drive shaft coupling. Ref: NTSB file 3-3657.
P39 Sikorsky S-55	23 Oct 79	1	D Davenport, Florida, USA. Main transmission support assembly separated. Ref: NTSB file 3-2438.
P40 Bell 47J-2A	8 Feb 80	0	S N. Westerheim, W. Germany. Engine mount. Ref: W. German file 3X0003.
P41 Hughes 369HS	26 Jun 80	0	S Herbert, New Zealand. Tail rotor transmission housing. Origin: microporosity. Ref NZ brief 80-076
P42 Bell 47G-2A Soloy	10 Jul 81	1	D Vivian, La. USA. Tail rotor driveshaft (corrosion fatigue). Ref: NTSB file 3-1999.
P43 Robinson R22	6 Aug 81	0	S Cincinnati, Oh. USA. Support bracket for tail rotor drive shaft damper. Ref: NTSB file 3-1715.
P44 Hiller UH-12E	8 Sep 81	0	S Brentwood, Ca. USA. Bevel gear in tail rotor gear box. Ref: NTSB file 3-3016.
P45 Agusta AB 205A-1	14 Jan 82	0	D Lyssjoen, Norway. Tail rotor drive shaft. REF: ICAO AAD 26/82.

Total Fatalities:	22
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* PART II *
* LISTING BY AIRCRAFT TYPE *
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* APPENDIX Q *
*
* LIST OF ROTARY-WING ACCIDENTS *
* - ORDERED BY AIRCRAFT TYPE *
*

ID	Aircraft	Accident	No. a	D	
No.	Type	Date	Dead	m	Remarks
<u>AEROSPATIALE SA 315 LAMA</u>					
<u>Airframe</u>					
L33	Aerospatiale SA 315B Lama	5 Apr 81	0	S	Kawakawa Bay, New Zealand. Top right tailboom longeron at bushing attaching tailplane. Poor weld repairing previous damage.
<u>AEROSPATIALE AS 316/3160 ALOUETTE III</u>					
<u>Engine/Transmission</u>					
N4f	Aerospatiale Alouette III	8 Aug 72	0	S	Greybull, Wy. USA. Main drive shaft (faulty machining).
N79	Aerospatiale SA 316 Alouette III	5 Sep 76	0	S	Grassy Narrows, Ont. Canada. Fuel injection wheel of fuel system. Engine: Turbomeca Artouste.
N87	Aerospatiale SA 316B Alouette III	21 Jun 77	0	D	Tokushima Pref., Japan. Stress concentration at flange on coupling shaft of engine.
<u>Miscellaneous</u>					
P16	S.N.I.A.S. SE 3160	21 May 72	0	S	Mayer, Ariz. USA. Clutch coupling bolts in universal joint. Tail rotor separated.
<u>AEROSPATIALE SA 318 ALOUETTE II</u>					
<u>Stabilizer Spar Tube</u>					
L15	Sud Aviation SA 318C Alouette II	22 Jan 74	0	S	Schaphusen, W. Germany. Stabilizer spar tube (prohibited weld repair).
L20	Sud Aviation SA 318B Alouette II	27 Feb 75	0	S	Oberpleis, W. Germany. Tubular spar of stabilizer.

Q-2

AIRCRAFT TYPE (ROTARY-WING)

Flight Controls

M20 Aerospatiale 16 Jun 77 0 S Hawkes Lake, Man. Canada.
SA 318 Tail rotor pitch change link. 3175 airframe
Alouette II hours.

Tail Rotor Shaft

P21 Sud Aviation 2 Jun 73 0 D Oberhoeffstadt, W. Germany.
SA 318C Tail rotor separated, fracture of tail rotor
Alouette II shaft.

AEROSPATIALE SA 330 PUMA

Engine

N99 Aerospatiale 7 May 78 2 S Atlantic City, N.J. USA.
SA 330J Puma Engine drive shaft failed, main rotor separated

AEROSPATIALE SA 341 GAZELLE

Miscellaneous

P24 Sud Aviation 15 Feb 75 0 S San Jose, Cal. USA.
SA 341G Tail rotor failure. Transmission cowling rubbed
against tail rotor incline shaft, eventually
fatigue-failing shaft.

AEROSPATIALE AS 350 ASTAR/ECUREUIL

Tail Rotor

K97 Aerospatiale 27 Feb 81 0 S St. Faustin, Que. Canada.
AS 350 Tail rotor failure (tail rotor control fitting).
Astar Fitting not properly seated on tail rotor blade
flange.

Flight Controls

M34 Aerospatial 4 May 81 0 S Gulf of Mexico.
AS 350D Astar Tail rotor pitch horn, PN 350A-12-1368.

Engine

N114 Aerospatiale 26 Jan 80 1 S Heaven Lake, Ont. Canada
AS 350 Astar Axial-stage blade, Avco Lycoming LTS-100 engine

N128 Aerospatial 11 Apr 81 0 S Edmond, Ok. USA.
AS 350D Astar Bendix fuel control speeder spring, P/N
2521724-2.

Miscellaneous

P35 Aerospatial 14 Dec 78 0 S Morgan City, La. USA.
AS 350C Tail rotor failure. Fatigue fracture of gear in
accessory drive assembly.

AEROSPATIALE SA 360 DAUPHIN

Engine

N107 Aerospatiale 20 Mar 79 0 S Fukushima Pref., Japan.
SA 360C Dauphin Flared part of fuel tube.

N122 Aerospatiale 21 Sep 80 0 S Kagoshima Pref., Japan.
SA 360C Dauphin Input flange of main gear box.

AGUSTA-BELL (See Bell)

AIR & SPACE 18

Main Rotor

J35 Air & Space 16 Feb 76 0 S Baton Rouge, La. USA.
18-A Main rotor blade drag strut link.

BELL 47/KAWASAKI KH-4

Main Rotor System

J8 Bell 47G-2 27 Aug 60 0 D Tremble Lake, Ont. Canada.
Main rotor blade grip, P/N 47-120-135-2M, at
barrel of grip (thread). Damaged in previous
accident.

J11 Bell 47J-2 29 Jun 64 0 S Waltham, Mass. USA.
Main rotor mast control stabilizer bar.

J20 Bell 47G-2 7 Apr 70 0 S Timmins, Ont. Canada.
Main rotor blade drag brace clevis. (Corrosion
fatigue). Threads.

J21 Bell 47G-2 8 Jun 71 1 D Branchville, N.J., USA.
Main rotor blade & grip assembly separated
in flight. Improper grip for Bell 47G-2. Role:
aerial application.

J22 Bell 47G-3B 8 Sep 71 0 S Brentwood, Cal. USA.
Main rotor stabilizer bar.

J23 Bell 47G-2 20 Mar 72 0 S Fremont, Iowa. USA.
Main rotor blade grip.

J39 Bell 47G-4A 23 Mar 78 2 D Morgan City, La. USA.
Main rotor failure. Rotor blade counterweight-
rod tie-bolt failed.

J46 Bell 47G-2 2 Aug 79 0 D Neufchateau, Belgium.
Clevis of one drag brace of main rotor blade.

J48 Bell 47G-2 24 Aug 79 0 S Niagara Falls, Ont. Canada.
Main rotor drag brace fitting.

J52 Bell 47G-2A 3 Sep 80 2 D Cottonport, La. USA.
Main rotor failure. Cyclic-pitch lateral torque
tube pivot shaft failed.

J54 Bell 47G-5 12 Jun 81 0 S Coloma, Wi. USA.
Main rotor separated. Corrosion & fatigue
fracture of stabilizer bar assembly, PN 140-
248-3.

Tail Rotor System

K1 Bell 47B 2 Jun 55 2 D Chapleau, Ont. Canada.
Tail rotor hub. Origin: bottom of inboard
undercut radius of spindle. Blade, blade grip
and spindle separated. Cracks in copper plating

Q-4

AIRCRAFT TYPE (ROTARY-WING)

K2	Bell 47G-2	4 Sep 63	0	S	Stewart, B.C. Canada. Tail rotor blade at thrust side of bore of blade hub.
K4	Bell 47G	3 May 64	0	D	McFarlane Lake, Ont. Canada. Tail rotor blade grip.
K5	Bell 47G	27 Jul 64	0	S	Plymouth, Mass. USA. Tail rotor blade.
K6	Bell 47J-2	7 Dec 64	3	D	Venice, La. USA. Separation of tail rotor blade, blade grip.
K7	Bell 47J-2	28 Mar 65	1	D	Boston, Mass. USA. Failure of tail rotor blade at blade grip.
K8	Agusta-Bell 47J	6 Jun 65	3	?	Helsinki, Finland. Tail rotor separated. Fracture in groove on thrust bearing seat of tail-rotor blade grip.
K12	Bell 47G-2	23 Nov 65	0	S	Kelso, Wash. USA. Tail rotor blade PN 47-642-102-49 inside grip fitting in stress relief fillet.
K13	Bell 47J-2	9 Dec 65	0	S	Refugio, Tex. USA. Tail rotor pinion shaft (improper assembly). Herding cattle.
K14	Bell 47J-2	14 Jan 66	0	S	East Boston, Mass. USA. Tail rotor blade inside grip fitting in stress relief fillet.
K15	Bell 47G-4	31 Jan 66	0	S	Burbank, Cal. USA. Tail rotor blade PN 47-642-102-53.
K16	Bell 47G-2	10 Feb 66	3	?	Sydney, Australia. Tail rotor retention bolt failed, followed by separation of the tail rotor assembly.
K17	Bell 47G-2	19 Feb 66	0	S	Gold Hill, N.C. USA. Tail rotor blade in grip fitting stress relief fillet.
K18	Bell 47G-3B-1	20 Mar 66	0	S	Fredericksted, Vi. USA. Tail rotor blade inside grip fitting in stress relief fillet.
K19	Bell 47G-3B	20 Jul 66	0	S	Santa Ana, Cal. USA. Tail rotor blade.
K22	Bell 47D-1	11 Oct 66	0	S	Ellensburg, Wash. USA. Tail rotor hub retention bolt PN 47-641-052-3.
K23	Bell 47G	12 Oct 66	0	S	Tonasket, Wash. USA. Tail rotor hub assembly bolt PN 47-641-052-3.

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AIRCRAFT TYPE (ROTARY-WING)

K25	Bell 47J-2	7 Nov 66	4	D	Carpenter, Calif. USA. Tail rotor blade.
K27	Bell 47G-4	13 Sep 67	2	S	La Place, La. USA. Shell of tail rotor blade.
K28	Bell 47J-2A	13 Dec 67	2	D	Hanalei, Hawaii, USA. Tail rotor blade. Lack of bonding material between shell and grip.
K29	Bell 47G-4A	3 Jan 68	0	D	Los Angeles, Calif. USA. Tail rotor blade. Hours on blade: 567. Role: police patrol.
K32	Bell 47G-4A	26 Oct 68	0	S	Chicago, Ill. USA. Tail rotor blades.
K33	Bell 47J-2	10 Jan 70	2	D	Fairbanks, Alaska, USA. Tail rotor blades separated.
K34	Bell 47G-2	14 Aug 70	0	S	Panama City, Fla. USA. Tail rotor blade retaining bolt PN 47-461-052-3.
K37	Bell 47G-3B-1	30 Aug 72	1	D	Tuba City, Ariz. USA. Tail rotor blades. Origin: internal bearing shoulder.
K39	Bell 47D	7 Jul 73	0	S	Anacortes, Wash. USA. Tail rotor blade yoke P/N 47-641-057-9.
K40	Bell 47G-5	8 Jul 73	0	S	Albuquerque, N. Mex. USA. Fracture of tail rotor blade. Previous damage to tail rotor pitch control system (75% of wires, cable #1, damaged by wear).
K41	Kawasaki KH-4	14 Jul 73	0	D	Chiba Pref., Japan. Rear edge fitting on parts of tail rotor blade.
K42	Agusta 47G-2	8 Sep 73	2	D	Solingen, West Germany. Separation of tail rotor, failure of bolt. Allowable flight time on blade exceeded.
K43	Bell 47G-2	18 Sep 73	0	S	Viola, Ark. USA. Tail rotor blade P/N 47-642-102-43 (blade grip area).
K44	Bell 47G-5	4 Oct 73	0	S	Fresno, Cal. USA. Tail rotor blade P/N 47-642-102-51.
K47	Bell 47G-2	21 Oct 74	1	D	Hullern, West Germany. Separation of tail rotor due to fracture at blade root. Initiated by corrosion.
K51	Agusta 47G-2	20 May 75	0	D	Feldkirchen, W. Germany. Tail rotor blade yoke P/N 47-641-57-9, (883 hours on part).

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AIRCRAFT TYPE (ROTARY-WING)

K52	Bell 47H-1	20 May 75	0	S	Nashville, Tenn. USA. Tail rotor hub bolt P/N 47-641-052-3. 499.8 hours on bolt (retirement life: 600 hours).
K53	Bell 47G-2	26 May 75	0	S	Denmark, Ar. USA. Yoke tail rotor hub P/N 47-641-057-009.
K54	Bell 47G-2	2 Jul 75	1	D	Napa, Calif. USA. Improperly-machined tail rotor hub failed, blade separated from rotor yoke. P/N 47-641-052-3. Role: crop dusting.
K55	Bell 47G-2A	20 Jul 75	0	S	Freer, Tex. USA. Tail rotor blade.
K57	Bell 47G-5	10 Aug 75	0	S	Chandler, Ariz. USA. Tail rotor blade.
K59	Bell 47G-2	26 Aug 75	0	S	Elliott, S.C. USA. Tail rotor grip P/N 47-642-102-37.
K60	Bell 47G-2	21 Jan 76	0	D	Bad Friedrichsh. W. Germany. Tail rotor separated, fracture of tail rotor yoke P/N 47-641-4057-9. Hours on yoke: 1080. Scheduled replacement time: 2500 hours.
K62	Bell 47G-3B-1	17 Jul 76	2	D	Petersburg Arkansas, USA. Tail rotor separated. Rotor blades 22 hours past mandatory change time.
K64	Bell 47G-2	6 Nov 76	1	D	Pigeon Forge, Tenn. USA. Tail rotor blade P/N 47-642-102-49.
K65	Bell 47G-2	1977	0	S	Bullo River, NT, Australia. Blade thrust bearing & blade grip failure. Prior damage to bearing.
K67	Bell 47D	29 Apr 77	0	S	Pori, Finland. Tail rotor blade.
K69	Bell 47G-5A	6 May 77	0	D	Russiaville, In. USA. Tail rotor blade. Role: aerial application.
K70	Bell 47G-2	14 Jun 77	0	S	Santa Monica, Cal. USA. Tail rotor, yoke rotor hub P/N 47-641-057-9K in tail rotor gear box.
K75	Bell 47G-1	18 Feb 78	0	S	Buttonwillow, Cal. USA. Yoke tail rotor hub P/N 47-641-057-9.
K77	Bell 47G	15 Jul 78	1	D	Loughman, Florida USA. Tail rotor blade P/N 47-642-102-051. Blade time 77.5 hours. Role: crop dusting.

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AIRCRAFT TYPE (ROTARY-WING)

K78	Bell 47G-2	16 Jul 78	0	S	Pigeon Forge, Tenn. USA. Tail rotor blade grip P/N 47-642-102. In service 468 hours.
K79	Bell 47G-2	12 Aug 78	0	S	Soledad, Cal. USA. Tail rotor blade (PN 47-642-K02-55) at insert on shank.
K80	Bell 47G-2	12 Aug 78	1	D	Omega, Georgia USA. Tail rotor blades. Role: crop spraying.
K87	Bell 47D	8 Jun 79	0	S	Parchman, Miss. USA. Tail rotor blade.
K88	Bell 47G-2	17 Jun 79	2	D	Jundah, Qld. Australia. Tail rotor blade grip at relief radius of outer bearing.
K90	Bell 47G	30 Jul 79	0	S	St. Andrews, Man. Canada. Tail rotor at blade grip.
K91	Bell 47J-2	14 Sep 79	5	D	Long Beach, Calif. USA. Tail rotor at inside diameter of blade grip. Time on blade: 536.4 hours. P/N 47-642-102.
K92	Bell 47G-2	8 Mar 80	0	D	Brentwood, Calif. USA. Tail rotor blade yoke P/N 47-641-057-9. Role: spraying.
K94	Bell 47D-1	22 Jul 80	0	S	Milan, Mi. USA. Tail rotor blade, PN 47-642-102-49, at outboard bearing relief radius of grip.
K95	Bell 47	1981	0	S	Stanthorpe, Queensland Australia. Tail rotor at blade grip.
K96	Bell 47G-2	20 Feb 81	0	S	Abbotsford, B.C. Canada. Tail rotor blade grip. Service life 300 hours. Blade had been on 3 different helicopters for a total of 1308 hours.

Tail-Rotor Drive Shaft Assembly

P3	Bell 47D-1	3 Jul 64	0	D	Harlingten, Texas USA. Fracture of tail rotor drive shaft assembly, causing loss of tail rotor. Role: aerial appl.
P4	Bell 47G-2	6 Mar 65	0	S	Barney's River Station, N.S. Canada. Tail rotor drive shaft (existing crack - probably from overload).
P11	Bell 47G-3B-1	25 Jun 68	0	S	Boron, Cal. USA. Tail rotor drive shaft assembly (improperly installed roller bearing).
P12	Bell 47G-3B-1	25 Jul 69	0	S	Fresno, Cal. USA. Tail rotor drive shaft assembly.

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AIRCRAFT TYPE (ROTARY-WING)

P14	Bell 47G-2A-1	10 Aug 71	2	D	Bellwood, Ill. USA. Tail rotor drive shaft yoke. Role: police patrol.
P15	Bell TH-13T (US Army)	6 Mar 72	0	D?	Al. USA. Tail rotor driveshaft assembly.
P25	Agusta 47G-4	18 Feb 75	0	S	Seringhausen, W. Germany. Tail rotor driveshaft.
P42	Bell 47G-2A Soloy	10 Jul 81	1	D	Vivian, La. USA. Tail rotor driveshaft, P/N 47-644-234-3, corrosion fatigue from end of cadmium plated sleeve.
<u>Tail Rotor Gear Box Pinion Shaft</u>					
P1	Bell 47D-1	30 Oct 51	1	S	Burk's Falls, Ont. Canada. Tail-rotor gear-box pinion shaft.
P28	Bell 47G-3B	12 May 76	0	S	Forks, Wash. USA. Tail rotor gear box, pinion shaft. Tail rotor separated.
<u>Airframe</u>					
L4	Bell 47G	26 Jun 67	0	S	Lincoln, Kans. USA. Tail rotor assembly broke off tail boom due to failure of housing yoke.
L9	Bell 47J	1970	0	S	Cook SA, Australia. Stabilizer tube assembly at inboard end. Severe fretting at inner & outer tubes.
L14	Bell 47G-5	25 Oct 73	2	D	Waynesburg, Pa. USA. Tail boom separated at STA 70, poor weld repairing previous damage.
L26	Bell 47K	22 May 76	0	D	Greenwich, R.I. USA. Failure of right elevator tubular spar. Elevator struck tail rotor.
<u>Flight Controls</u>					
M2	Bell 47G-2	11 Jul 64	0	S	Wall, S.D. USA. Tail rotor pitch control system.
M5	Bell 47G-2	2 Dec 67	0	S	Lahabra, Cal. USA. Tail rotor pitch change link (improper installation). Tensile strength below mfr requirements.
M7	Bell 47G-5	23 Nov 68	0	S	Rochester, Mass. USA. Failure of shaft to cylinder servo valve, cyclic pitch control system.
M12	Bell 47G	5 Mar 70	0	S	Fort Worth, Tex. USA. Sheared delta hinge bolt caused failure of pitch control bearing & tail rotor separation.
M13	Bell 47G-5	21 Jan 72	0	S	Koloa, Hawaii. USA. Cyclic-pitch control boost cylinder.

M16	Bell 47G-3B-1	5 Sep 74	1	D	Ogden, Utah USA. Lost lateral cyclic control. Separation of shaft P/N 47-725-853-5 due to off-centre drilled hole.
M17	Bell 47G-4A	10 Jan 76	0	S	Encinal, Tex. USA. Tail rotor pitch change link.
M22	Kawasaki KH-4	9 Aug 77	0	D	Ibaragi Pref., Japan. Origin: Pitting corrosion at support parts of torque tube assembly.
M24	Bell 47G-5	1978	0	S	Winton, Qld. Australia. Tail rotor pitch-change rod. Role: cattle mustering.
M26	Bell 47G-4	12 Jun 78	0	S	Bremm A.D. Mosel, W. Germany. Tail rotor pitch control system.
M27	Westland 47G-3	11 Jul 78	0	D	Wintringen, W. Germany. Tail rotor pitch control system, steering cable
M30	Agusta 47J-3	11 Jun 79	0	S	Iphofen, W. Germany. Tail rotor pitch control system.
M31	Bell 47G-3B KH-4	11 Jun 80	0	D	Ibaragi Pref., Japan. Fitting bolt of forward & aft cyclic control rod.
M32	Bell 47G-2A	3 Sep 80	2	D	Cottonport, La. USA. Lateral control torque tube pivot shaft of cyclic pitch control system.
M35	Westland 47G-3B-1	4 Jul 81	0	S	Koldingen, W. Germany. Main rotor cyclic pitch control. Damper shaft in region of clamp.
<u>Engine/Transmission</u>					
N1	Bell 47D-1	15 Sep 50	0	S	Liege, Belgium. Blade of engine cooling fan.
N4	Bell 47G	14 Oct 63	0	S	Porcupine River, Que. Canada. Connecting rod bolts at thread.
N7	Bell 47G	27 Sep 64	0	S	Bakersfield, Cal. USA. Exhaust rocker arm bolt, no. 3 cylinder.
N8	Bell 47J-2	22 Dec 64	0	S	Philadelphia, Pa. USA. No. 1 cylinder connecting rod.
N13	Bell 47D-1	12 Mar 66	0	S	Shelby, Miss. USA. No. 2 connecting rod.
N15	Bell 47G-3B-1	16 Aug 66	0	S	Telegraph Creek, B.C. Canada. Fan blade (improper installation).

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AIRCRAFT TYPE (ROTARY-WING)

N18	Bell 47J-2	26 Oct 66	0	S	Brookline, Mass. USA. Teeth in fan drive gears, P/N 47-620-207 & -530.
N19	Bell 47G-3B	4 Jan 67	0	S	Glenwood Springs, Colo. USA. Piston pin, no. 6 cylinder.
N25	Bell 47G-3B-1	24 Jun 68	0	S	Fuller Lake, Y.T. Canada. Wrist pin of piston, no. 1 cylinder.
N30	Bell 47G-3B-1	23 Jul 69	0	S	Stirling City, Cal. USA. External supercharger (turbine wheel).
N33	Bell 47J-2	22 Apr 70	0	S	Piscataway, N.J. USA. Free wheeling gear in main rotor drive system. P/N 47-620-531-1.
N38	Bell 47G-4-A	10 Sep 71	0	S	Shelbyville, Ky. USA. Bolt to # 6 con rod.
N49	Bell 47G-3B-1	9 Nov 72	3	D	Piz Muttler, Switzerland. Cooling fan blade (fretting at bolt).
N54	Bell 47G-4A	5 Apr 73	0	S	Washington, D.C. USA. No. 6 cylinder conrod cap bolt.
N58	Bell 47G-3B-2	1974	0	S	Mt. Bundy Stn. Australia. Connecting rod bearing. Origin: galling on bearing borecon rod.
N71	Bell 47J-2	22 Oct 75	0	S	Conshocken, Pa. USA. No. 5 connecting rod P/N LW-13422.
N85	Bell 47G-4A	8 Jun 77	0	D	Boitzenhagen, W. Germany. Connecting rod big-end bearing.
N92	Bell 47G-3B-1	2 Oct 77	0	S	Alsea, Ore. USA. Transmission rotor drive system: bogus part in clutch assembly. Central hub separated from centrifugal clutch drum. P/N 47-620-691, web below thickness requirement.
N97	Bell 47G	6 Mar 78	0	S	New Bern, N.C. USA. Crankshaft (no. 1 conrod journal).
N102	Bell 47G-4A	8 Nov 78	0	S	Hokkaido, Japan. # 2 connecting rod. Origin: pitting corrosion.
N104	Bell 47	1979	0	D	Timber Creek, Australia. Turbo wastegate seal.
N131	Bell 47G-4A	28 Apr 81	0	S	Birds Hill, Man. Canada. Camshaft gear attachment bolts, improper assembly.
N132	Bell 47A-J2	29 Apr 81	0	S	Whitehorse, Y.T. Canada. Engine cooling fan assembly mounting studs.

N134 Bell 47J-2 26 May 81 0 S Branson, Mo. USA.
#6 con rod.

Landing Gear
04 Bell 47G-2 11 May 69 0 S Lindenhurst, N.Y. USA.
Skid assembly.

Miscellaneous
P40 Bell 47J-2A 8 Feb 80 0 S N. Westerheim, W. Germany.
Engine mount.

BELL 204 (UH-1/B/M IROQUOIS)

Tail Rotor
K21 Bell 204B 8 Oct 66 11 D Morgan City, La. USA.
Tail rotor.

Airframe
L6 Bell 204B 22 Mar 68 3 ? Bass Strait, Australia.
Tail fin structure (tail rotor imbalance).
Trunnion thrust washer not installed during
maintenance.

L27 Bell 204B 11 Feb 77 0 D Shizuoka Pref., Japan.
Fitting flange of vertical fin.

Landing Gear
03 Bell 204B 4 Apr 68 0 S Kenai, Alas. USA.
Rear float cross tube.

06 Bell TH-1G 16 May 75 0 S Tx. USA.
Iroquois
(US Army)
Left forward & aft cross tubes failed above the
skid saddles.

07 Bell 204B 6 Feb 77 0 S Sonderstromfjord, Greenland.
Landing gear floats, right hand side of rear
cross tube.

Engine
N50 Bell UH-1B 18 Jan 73 0 S Al. USA.
Engine power shaft.

N100 Bell UH-1M 19 Oct 78 0 S Pa. USA.
Iroquois
(US Army)
Engine (gear assembly).

Antenna
P6 Bell 204B 28 May 66 1 D Lincoln Sea, Canada.
Radio antenna tube (attached to vertical stab-
ilizer) failed from fatigue & struck tail
rotor, causing failure. Origin: rivet hole.

BELL MODEL 205 (UH-1D/H IROQUOIS)

Tail Rotor
K45 Bell UH-1H 23 Jul 74 0 S Mo. USA.
Iroquois
(US Army)
Tail rotor grip.

K46 Bell UH-1H 19 Aug 74 0 S Fl. USA.
Iroquois
(US Army)
Tail rotor at blade grip.

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AIRCRAFT TYPE (ROTARY-WING)

K50 Bell UH-1H 13 May 75 0 S In. USA.
Iroquois Tail rotor (stiffener spar).
(US Army)

K58 Bell UH-1H 22 Aug 75 0 D Ky. USA.
Iroquois Tail rotor grip assembly.
(US Army)

Engine
N64 Bell UH-1H 23 Oct 74 0 S Tn. USA.
Iroquois Engine (blade).
(US Army)

N72 Bell UH-1H 30 Oct 75 3 D Al. USA.
Iroquois Engine (turbine rotor).
(US Army)

Miscellaneous
P23 Bell UH-1H 19 Jun 74 0 S S.C. USA.
Iroquois (US Army) Connector failed, causing yaw.

BELL 205A-1

Tail Rotor
K36 Bell 205A-1 29 May 72 11 D Dulac, La. USA.
Tail rotor blades separated (grips failed).

Airframe
L25 Bell 205A-1 23 Apr 76 12 D Gulf of Mexico near Louisiana USA.
Tail boom/fuselage attach fittings.

Flight Controls
M15 Bell 205A-1 21 Jul 74 0 D Umiat, Alaska USA.
Tail rotor pitch-change chain failed, causing failure of tail rotor.

M28 Bell 205A-1 18 Aug 78 1 D Dennison Mines, BC, Canada.
Tail-rotor pitch-change chain. P/N 204-001-739-3. 35 hours on chain.

Pontoon Cross-Tube
O10 Bell 205A-1 18 Jul 80 1 D Arcola-Houston airport, Texas USA.
(on floats) Front cross tube of pontoon. Crack on right-forward cross tube where the support saddle fitting was riveted.

Tail Rotor Drive Shaft
P45 Agusta 14 Jan 82 0 D Lyssjoen, Norway.
AB 205A-1 Tail rotor drive shaft.

BELL 206 JETRANGER/LONGRANGER

Main Rotor System
J25 Bell 206B 10 Aug 72 4 S Embar, Labrador, Canada.
Main rotor-blade retention strap fitting.

J31 Bell 206A 1 Feb 75 1 D Milford, Connecticut, USA.
Main rotor separated in flight. Lower main rotor pitch-change mechanism clevis.

J32 Bell 206A 23 Oct 75 4 D Hiddensen, West Germany.
Main rotor blade.

J34	Bell 206B	17 Apr 76	1	D	Leeville, La. USA. Main rotor tension-torsion strap failed, causing rotor failure.
J36	Bell 206B	11 Dec 76	0	S	Morgan City, La. USA. Main rotor tension torsion strap separated.
J37	Bell 206B	18 Feb 77	0	S	Atlanta, Ga. USA. Main rotor trunnion separated.
J38	Bell 206B	17 Mar 77	1	D	Intracoastal City, La. USA. Main rotor tension-torsion strap.
J50	Bell 206L	9 Jan 80	0	S	Opinaca, Que. Canada. Main rotor trunnion (lack of tempering). Origin: spindle fillet. Airframe 3226 hours.
<u>Tail Rotor</u>					
K89	Bell 206B	21 Jul 79	0	S	Alpine, N.J. USA. Fatigue fracture of tail rotor blade. ELT antenna separated due to fatigue. Tail rotor grooves match ELT antenna.
<u>Flight Controls</u>					
M8	Bell 206A	15 Mar 69	0	D	Springfield, Ohio. USA. Right-hand cyclic bell-crank support.
M9	Bell 206A	20 Jul 69	1	S	Mile 142 Alaska Highway, BC, Canada. Bearing connecting pitch link to swash-plate outer ring went out of position. Pitch link lower clevis contacted the swash-plate horn, causing abnormal bending loads, & fatigue failure of clevis.
<u>Engine/Transmission</u>					
N2E	Bell 206A	31 Aug 68	0	S	Medfra, Alas. USA. First stage compressor vanes.
N34	Bell 206A	25 Apr 70	0	S	Morgan City, La. USA. Blade of 2nd stage gas producer turbine wheel. P/N 6857912.
N35	Bell 206A	21 May 70	0	S	Pennsauken, N.J. USA. Two 5th stage compressor blades.
N36	Bell 206A	19 Jan 71	0	S	Lac Duprat, Que. Canada. Compressor rotor assembly's 3rd stage com- pressor blades (abnormal vibrations).
N37	Bell 206A	9 Jun 71	0	D	Gulf of Mexico off Louisiana, USA. 2nd phase turbine wheel.
N45	Bell 206A	2 Aug 72	0	S	Rocky Hill, Conn. USA. Compressor blade (overhaul overdue).
N68	Bell 206A	30 Jul 75	0	S	Barter Island, Ak. USA. 5th stage compressor wheel blades.

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AIRCRAFT TYPE (ROTARY-WING)

N76	Bell 206	21 Jul 76	0	S	Eastmain, Que. Canada. Engine air pressure line at flared end in pressure sleeve. Allison 250 engine.
N81	Bell 206L LongRanger	17 Dec 76	0	D	Anchorage, Alaska USA. Failure of turbine blade, turbine wheel.
N95	Bell 206B	1978	0	D	Queensland Australia. Drive shaft between engine & rotor gear box.
N98	Bell 206B	9 Apr 78	0	S	East Meadow, N.Y. USA. Fuel pump drive splines.
N108	Bell 206B	3 Jun 79	0	D	Morgan City, La. USA. Turbine blade.
N111	Bell 206B	11 Sep 79	0	S	Merrimack, N.H. USA. PC line at fuel control.
N116	Bell 206L-1 LongRanger	6 May 80	2	D	Gibson, La. USA. #4 bearing failed in reduction gear assembly.
N118	Bell 206A	13 Jun 80	0	D	McKinley Bay, NWT Canada. 1st stage gas producer turbine wheel. Thermal fatigue precrack in outer rim of wheel. Wheel hours: 742 (approved life: 750).
N124	Bell 206B	31 Dec 80	0	S	Patterson, La. USA. 2nd stage turbine wheel blade.
N126	Bell 206B	22 Feb 81	0	S	Niigata Pref., Japan. 3rd stage blade.
N127	Bell 206L-1 LongRanger	25 Mar 81	0	S	Gulf of Mexico, USA. Compressor, spline adapter, PN 6899243.
N130	Bell 206L-1 LongRanger	25 Apr 81	0	S	Leeville, La. USA. Turbine nozzle.

Pylon Support Link

P19	Bell 206B	19 Feb 73	5	D	Morgan City, La. USA. Pylon support link failed, causing complete failure of main rotor/transmission assembly
P20	Bell 206B	22 Feb 73	1	D	Amelia, La. USA. Right pylon support link failed, causing in-flight failure of main rotor system.

BELL OH-58 KIOWA

Main Rotor

J43	Bell OH-58A Kiowa (US Army)	25 Aug 78	3	D	Germany. Main rotor blade assembly.
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Engine

N53	Bell OH-58A Kiowa (US Army)	29 Mar 73	0	S	N.C. USA. Engine compressor rotor.
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N61 Bell OH-58A 9 Apr 74 0 S Germany.
Kiowa (US Army) Engine compressor rotor.

N62 Bell OH-58A 10 Sep 74 0 S Ky. USA.
Kiowa (US Army) Compressor rotor.

N113 Bell OH-58A 10 Jan 80 0 D? Germany.
Kiowa (US Army) Engine gear assembly.

Miscellaneous

P34 Bell OH-58A 1 May 78 0 S Wa. USA.
Kiowa (US Army) Power loss (tube assembly failure)

BELL MODEL 209 (AH-1 HUEYCOBRA)

Main Rotor

J27 Bell AH-1G 26 Nov 73 2 D Ok. USA.
HueyCobra Main rotor blade assembly.
(US Army)

Flight Controls

M33 Bell AH-1S 23 Mar 81 0 D Germany.
HueyCobra Failure of tube assembly.
(US Army)

Engine

N41 Bell AH-1G 1 Mar 72 0 S Vn. USA.
HueyCobra Engine (compressor blade).
(US Army)

N101 Bell AH-1G 31 Oct 78 0 D Al. USA.
HueyCobra Engine (pin).
(US Army)

BELL 212 TWIN TWO-TWELVE

Main Rotor

J33 Bell 212 3 Nov 75 9 D Gulf of Mexico, near Louisiana USA.
Main rotor blades separated. 866 hours on blade

Flight Controls

M36 Bell 212 11 Sep 81 0 S Wadlin Lake, Alta. Canada.
"White" tail rotor pitch link. Premature wear
of rod end bearing produced abnormal loading
& fatigue initiation.

BELL 214

Tail Rotor

K82 Bell 214 11 Nov 78 1 D Col de Marie Blan, France.
Tail rotor and rear transmission box separated.
Vibration caused by flapping of tail rotor as a
result of abnormal wear of universal joint. 3
fastening bolts on tail rotor broke in fatigue.

Airframe

L29 Bell 214B-1 31 May 77 2 D Liberty, Wash. USA.
Separation of vertical fin.

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AIRCRAFT TYPE (ROTARY-WING)

	<u>Engine/Transmission</u>				
N83	Bell 214B-1	30 May 77	0	S	Clover Bar, Alta. Canada. Engine accessory drive inner bevel gear. Avco Lycoming T-5508D engine. 43 airframe hours.
N89	Bell 214B-1	30 Jul 77	0	S	Sawyers Bar, Cal. USA. Accessory inner bevel gear P/N 2-070-005-02.

BELL 222

	<u>Flight Controls</u>				
L35	Bell 222	16 Apr 82	3	D	Hinton, Ok. USA. Main rotor blade control link.

BENSEN B-8M GYRO-COPTER

	<u>Main Rotor</u>				
J10	Bensen B-8M Gyro-Copter	19 Jun 64	1	D	Nacogdoches, Tex. USA. Spindle holding main rotor to mast failed, allowing rotor to separate.
J13	Bensen B-8M Gyro-Copter	28 Jan 67	1	D	Chino, Calif. USA. Main rotor separated in flight. Rotor spindle not made to specifications.

	<u>Flight Controls</u>				
M4	Bensen B-8M Gyro-Copter	25 Sep 66	1	D	Benton, Pa. USA. Head fork assembly strap.

	<u>Landing Gear</u>				
011	Bensen B-8M	28 Sep 80	0	S	St. Joseph, Il. USA. Support bar for main landing gear.

BOEING VERTOL MODEL 42 (See Vertol Model 42)

BOEING VERTOL MODEL 44 (See Vertol Model 44)

BOEING VERTOL MODEL 107/CH-46

	<u>Main Rotor</u>				
J28	Boeing Vertol CH 113A Voyageur (Canadian Forces)	20 Mar 74	3	D	Edmonton, Alta. Canada. Forward red rotor blade failed. Origin: corrosion pit on main D spar at mid-chord.

	<u>Main Rotor Shaft</u>				
P29	Boeing-Vertol H-46 Sea Knight (US Navy or US Marines)	16 May 76	4	?	Mediterranean Sea off carrier USS Guadalcanal. Crack in main rotor shaft.

	<u>Engine/Transmission</u>				
N5	Boeing Vertol 107-II (Japanese Self- Defence Force)	14 Oct 63	6	D	Jamaica, N.Y USA. Fatigue failure of quill drive shaft due to contamination of the lubrication system in aft transmission assembly.

Thrust Deck
P13 Kawasaki/ 1971 ? ? Japan.
Boeing KV-107 Failure of thrust deck, connecting the power-drive system to the fuselage, causing rear rotor to separate.

BOEING VERTOL CH-47 CHINOOK

Main Rotor Blade
J24 Boeing Vertol 10 May 72 34 D Vn. USA.
CH-47A Chinook Aft green main rotor blade (spar).
(US Army)

Main Rotor Shaft
P31 Boeing Vertol 15 Jul 77 1 D Germany.
CH-47C Chinook Main rotor shaft.
(US Army)

Engine or Transmission
N63 Boeing Vertol 18 Oct 74 5 D Middletown, Pa. USA.
CH 147 Chinook Combining transmission spiral bevel gear.
(Canadian Forces) Origin: non-metallic inclusion on gear flange.

N67 Boeing Vertol 13 Jun 75 0 D Germany.
CH-47C Chinook Blade in engine.
(US Army)

N106 Boeing Vertol 14 Mar 79 0 D? S. Korea.
CH-47C Chinook Bevel gear in combining transmission.
(US Army)

N117 Boeing Vertol 4 Jun 80 0 S S. Korea.
CH-47C Chinook #1 engine exploded (gear assembly failure).
(US Army)

BRANTLY B-2

Main Rotor
J26 Brantly B-2B 15 Aug 72 2 D Duxbury, Mass. USA.
Red main rotor blade separated in flight.

Tail Rotor
K9 Brantly B-2 28 Jun 65 0 S Prophetstown, Ill. USA.
Tail rotor blades (unapproved mod).

K30 Brantly B-2B 6 Feb 68 2 D Lakeside Nebr. USA.
Tail-rotor blade spar, inside bearing boss radius.

K35 Brantly B-2 12 Jun 71 0 S Middleton, N.S. Canada.
Tail rotor blade. Origin: inner wall surface of grip at thrust bearing shoulder relief radius (tool mark).

K76 Brantly B-2B 14 Jul 78 1 S Nome, Alaska USA.
Tail rotor blade at radius inboard of thrust bearing shoulder at leading edge. Role: herding animals. Matl: 2014-T6. Hours on blades: 2200 (service life: 2500).

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AIRCRAFT TYPE (ROTARY-WING)

K83	Brantly B-2B	15 Dec 78	2	D	Sloan, Iowa USA. Tail rotor blade.
K100	Brantly B-2B	10 Jun 81	2	D	Chesterton, In. USA. Tail rotor blade (blade shank outboard of double bearing location).
<u>Airframe</u>					
L7	Brantly B-2B	6 Jul 68	0	S	Monroeville, Pa. USA. Right stabilizer spar tube.
<u>Engine</u>					
N11	Brantly B-2B	25 Sep 65	0	S	Denver, Colo. USA. Connecting rod cap bolt.
N27	Brantly B-2	30 Mar 69	0	D	Aberdeen, Md. USA. No. 4 piston connecting-rod attach bolt.
<u>Tail-Rotor Drive-Shaft Assembly</u>					
P7	Brantly B-2B	3 Mar 67	0	S	Cedar Rapids, Iowa. USA. Tail rotor drive shaft assembly.
P22	Brantly B-2	21 Nov 73	0	D	North Bergen, N.J. USA. Vertical drive of tail rotor drive shaft ass- embly at bolt holes 1" from upper end of shaft.
<u>Pylon Bearing Shaft</u>					
P18	Brantly B-2B	9 Nov 72	1	D	Oxford, England. Failure of the outboard pylon bearing shaft of the main rotor blade. Blade separated.

BRANTLY 305

<u>Main Rotor</u>					
J14	Brantly 305	29 May 67	2	D	Chamblee, Ga. USA. Brinelled main-rotor hub clevis bearings caused torsion strap assembly to fail in fatigue, & main rotor separated.
J15	Brantly 305	3 Nov 67	3	D	Taswell, Ind. USA. Main rotor clevis bearings seized, main rotor torsion straps failed & main rotor separated.
<u>Tail Rotor System</u>					
K11	Brantly 305	23 Aug 65	0	S	Millheim, Pa. USA. Tail rotor blades.
K38	Brantly 305	23 May 73	0	S	Denver, Colo. USA. Tail rotor hub.
K56	Brantly B-305	31 Jul 75	0	D	100 km from Reykjavik, Iceland. Tail rotor (blade hub). Possibly improper installation.
<u>Engine</u>					
N69	Brantly B-305	29 Sep 75	0	D	Budir, Faskruds fjordur, Iceland. Piston rod. Engine time far above authorized lifetime.
<u>Miscellaneous</u>					
P5	Brantly 305	18 May 66	0	S	Annapolis, Md. USA. Right oil cooling fan shaft. P/N 1385055.

P30 Brantly 305 1 Oct 76 0 D Astey Village, England.
Main rotor gearbox, forward attachment bolt.
Origin: corrosion pit in shank of bolt.
Airframe hours: 358.

CIERVA AIR HORSE

Flight Controls
M1 Cierva 13 Jun 50 3 ? England.
Air Horse Carrier driving link of front rotor.

ENSTROM F-28A

Tail Rotor System
K10 Enstrom 11 Jul 65 0 S Marquette, Mich. USA.
F-28 Tail rotor blades.
K31 Enstrom 10 May 68 0 S Milwaukee, Wis. USA.
F-28 Rotor spindle of tail rotor.
K61 Enstrom 4 Apr 76 0 S Blythe, Cal. USA.
F-28A Tail rotor blades.
K63 Enstrom F-28A 9 Aug 76 2 D Enon, Ohio USA.
Tail rotor blades separated. Spindle machined
below specifications, & tool marks in machined
area.
K66 Enstrom 8 Jan 77 0 S Fallentimber, Pa. USA.
F-28C Tail rotor spindle P/N 28-15202.
K72 Enstrom F-28 31 Jul 77 0 S Montgomery, Ala. USA.
Reversed installation of bearing P/N Q30203 DT
in tail rotor pitch control system caused tail
rotor failure.

Airframe
L21 Enstrom 5 Jul 75 0 S San Francisco, Cal. USA.
F-28A Tail boom attach bolt.

Engine/Transmission
N65 Enstrom F-28A 1975 0 S Curlew Waterhole, Australia.
RH front transmission bolt failed, resulting in
failure of collective pitch control bellcrank.

N82 Enstrom 13 Jan 77 0 S Boynton Beach, Fla. USA.
F-28A Transmission rotor drive system: clutch
assembly, idler yoke P/N 28-13223.

Tail Rotor Drive Shaft
P32 Enstrom 7 Feb 78 0 S Waverley, New Zealand.
F-28C Tail rotor drive shaft. Fatigue strength
reduced by softened condition & surface
decarburisation. AISI 4130 steel.

P33 Enstrom 17 Feb 78 0 S Centre Hill, New Zealand.
F-28A Tail rotor drive shaft. Fatigue strength
reduced by softened condition & surface
decarburisation.

FAIRCHILD HILLER FH-1100

<u>Main Rotor</u>					
J17	Hiller FH-1100	15 Nov 69	0	S	Nordegg, Alta. Canada. Lower tine of main rotor blade cuff, at blade retention bolt hole (fretting). Undertorquing of main rotor retention bolt.
<u>Airframe</u>					
L18	Hiller FH-1100	24 Nov 74	1	D	Freeport, NY USA. Aft tail boom separated, cracks in tail fin spar channel. Role: police patrol.
<u>Flight Controls</u>					
M10	Fairchild Hiller FH-1100	21 Jul 69	1	?	Opapimiskan Lake, Ont. Canada. Swash-plate input push-rod assembly at rod-end retainer.
M14	Hiller FH-1100	30 Jun 74	5	D	Umiat, Alaska USA. Swashplate assembly, cracks at two bolt holes.
<u>Engine/Transmission</u>					
N24	Fairchild Hiller FH-1100	8 Jun 68	0	S	Fort Nelson, B.C. Canada. Forward diaphragm of centre disc on front end diaphragm pack of power transmission shaft.
N28	Hiller FH-1100	11 Jun 69	3	D	Niwelin Lake, NWT, Canada. Bendix engine-to-transmission driveshaft.
N44	Hiller FH-1100	19 Jul 72	0	S	North Bend, Wash. USA. 1 blade from each stage of 5th & 6th compressor wheel.
N75	Fairchild FH-1100	2 Jul 76	3	D	Porter Lake, NWT, Canada. Transmission, main-rotor drive-shaft. Bendix coupling failed in flight. 6775 airframe hours.
N94	Hiller FH-1100	22 Dec 77	0	D	Walton, Oregon USA. Left transmission lift link strut failed. Role: aerial logging.
N109	Fairchild FH-1100	25 Jul 79	0	S	Riviere Eternite, Que. Canada. Abraidable plastic compressor case liner was severely eroded on one side. Disturbed airflow. Fourth stage compressor blade failed.

FAIREY AVIATION FB-1 GYRODYNE

<u>Main Rotor System</u>					
J4	Fairey Aviation FB-1 Gyrodyne	17 Apr 49	2	D	Great Britain. Rotor hub. UK's 1st fatal helicopter crash.

HILLER MODEL 360/UH-12

<u>Main Rotor</u>					
J45	Hiller UH-12E	11 May 79	0	S	Independence, Ore. USA. Main rotor failed. Incidence push rod end bearing failed at outer shell.

J47	Hiller UH-12E	10 Aug 79	0	S	Tuscaloosa, Al. USA. Pin, main rotor, outboard, tension torsion bar P/N 51452.
	<u>Tail Rotor</u>				
K20	Hiller UH-12E	22 Jul 66	2	D	Cochrane, Ontario, Canada Tail-rotor spar at lower outboard trunnion attachment bolt hole.
K24	Hiller UH-12C	2 Nov 66	0	S	Mineral Wells, Tex. USA. Tail rotor hub.
K26	Hiller UH-12E	2 Sep 67	2	D	Near Ft. Nelson, B.C. Canada. Tail-rotor spar tube. Origin: fretting corrosion on outer surface of tube at bottom outboard attachment hole. Third rotor spar fatigue failure from this cause.
K68	Hiller UH-12E	6 May 77	0	S	Camerons Creek, New Zealand. Cuff (cuff & trunnion assembly of tail rotor) at bolt hole.
K73	Hiller UH-12E	1978	0	D	Wyndham, Australia. Tail rotor blade separated.
K98	Hiller UH-12E	3 Apr 81	0	D	Miami, Fl. USA. Tail rotor blade failure. Bogus part. Blade composed of impure skin material, rivets in- stalled incorrectly, & bal screw not lock wired
	<u>Flight Controls</u>				
M3	Hiller UH-12E	7 Jul 65	0	D	Meeteetse, Wyo. USA. (Cyclic pitch control system). Bolt holding wobble plate pylon not properly secured, allowing plate to fail in fatigue. Role: aerial application.
M18	Hiller UH-12E	14 Mar 76	0	D	Bluff, Ut. USA. (Cyclic pitch control system). Wobble plate pylon failed.
M21	Hiller 12EJ3	28 Jul 77	1	D	Ketchikan, Alaska USA Cyclic pitch control system failed. Cyclic isolation-link hollow-shank rod-end bearing had same ID no. as correct solid rod end. Role: aerial survey.
M25	Hiller UH-12E	19 May 78	0	S	Karamea, New Zealand. Left tail rotor control cable, near pulley.
M29	Hiller UH-12J	20 Nov 78	0	S	Between Arawhata & Waitoto Rivers, New Zealand. Main rotor control "paddles" separated. Origin: fretting at inboard bolt holes by trunnion bearing cuffs.
	<u>Engine/Transmission</u>				
N2	Hiller 360	7 Feb 52	1	D	Toussus-le-Noble, France. Connecting rod, no. 2 cylinder.

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AIRCRAFT TYPE (ROTARY-WING)

N9	Hiller 360	6 Apr 65	0	S	Ludham, UK. No. 4 piston.
N16	Hiller UH-12E	24 Aug 66	0	S	Rainbow Lake, Alta. Canada. No. 1 connecting rod (inadequate torquing).
N17	Hiller UH-12E	11 Sep 66	0	S	Happy Camp, Cal. USA. No. 4 cylinder connecting rod bolt.
N29	Hiller UH-12E	9 Jul 69	0	S	Bettles, Alas. USA. No. 5 cylinder con rod cap and bolts.
N40	Hiller 360-UH	28 Feb 72	2	D	England. Failure of a planet gear in first-stage reduction housing, causing main rotor to detach
N43	Hiller UH-12E	7 Jul 72	0	S	Umiat, Alas. USA. # 3 conrod and cap (fretting).
N59	Hiller UH-12E	2 Feb 74	0	S	National Park, New Zealand. No. 6 cylinder con-rod bolt.
N86	Hiller 12	15 Jun 77	0	S	Lemory, B.C. Canada. Crankshaft. Engine: Avco Lycoming VO-540.
N103	Hiller UH-12 Soloy	22 Dec 78	0	S	Lacomb, Ore. USA. Tachometer generator.
N105	Hiller UH-12	1979	2	D	Dorisvale, NT Australia. Studs connecting torsion coupling to upper coupling.
N119	Hiller 12	5 Jul 80	0	S	Lockwood Lake, Sask. Canada. No. 1 connecting rod. Origin: galled area on bore of rod at crankshaft end.
P2	<u>Miscellaneous</u> Hiller UH-12E	23 Apr 63	0	S	Shalalth, B.C. Canada. Tail rotor pinion gear.
P10	Hiller 12B	27 May 68	0	S	Arroyo Grande, Cal. USA. Tail rotor drive shaft assembly (centering pin of cardan joint).
P44	Hiller UH-12E	8 Sep 81	0	S	Brentwood, Ca. USA. Bevel gear P/N 25211-5 in tail rotor gear box.

HILLER FH-1100 (See Fairchild Hiller FH-1100)

HUGHES 269

J12	<u>Main Rotor</u> Hughes 269A	14 Oct 64	2	D	Houston, Texas USA. Main rotor. Lack of lubrication in bearings.
K3	<u>Tail Rotor</u> Hughes 269A	9 Feb 64	0	S	Opa Locka, Fla. USA Tail rotor blades.

K48	Hughes 269C	15 Jan 75	2	D	Barnby Moor, Notts., England. Tail rotor spar (corrosion pit).
K74	Hughes 269B	10 Feb 78	0	D	Tahola, Wa. USA. Tail rotor swashplate assembly at threads.
	<u>Airframe</u>				
L1	Hughes 269A	19 Aug 65	0	S	Miami, Fla. USA. Looseness of stabilizer lower attach bolt caused upper attach bolt to fatigue fail, stabilizer came off.
L3	Hughes 269B	1 Mar 66	0	S	Memphis, Tenn. USA. Loose tail rotor abrasive strip caused vibration, failing improper rivets in stabilizer mount bracket.
L10	Hughes 269B	27 Sep 70	1	D	Ste. Pie de Bagot, Que. Canada. Tailboom left support strut lower fitting (fretting). Misalignment during rebuild after previous accident.
L12	Hughes 269B	11 May 72	0	S	Saratoga, N.Y. USA. Tail boom attach strut.
L16	Hughes 269B	21 Feb 74	0	S	Saitama Pref., Japan. Cluster fitting of centre frame. Crack origin: pitting corrosion.
L17	Hughes 269B	27 May 74	0	S	Las Vegas, Nev. USA. Horizontal stabilizer attachment PN 2516.
L19	Hughes 269B	27 Nov 74	0	D	Omahaki Station, New Zealand. Attachment lug of port tailboom support strut.
L22	Hughes 269B	15 Jul 75	0	D	Niigata Pref., Japan. Stress concentration at fitting metal and rivet of horizontal stabilizer.
L23	Hughes 269C	17 Sep 75	0	D	Rovaniemi Airport, Finland. Gear box to fuselage fastening strut broke, allowing rotor steering system to move freely.
L24	Hughes 269A	14 Oct 75	0	S	Wichita, Kans. USA. Tail boom end fitting (surface scratch).
L28	Hughes 269B	30 May 77	0	S	Evart, Mich. USA. Tail boom center attach fitting P/N 269A-2324-7
L32	Hughes 269C	15 Dec 79	1	D	West Milton, Ohio, USA. Separation of tail boom, tailboom centre attach fitting.
L34	Hughes 269A	29 Aug 81	0	S	Campbell River, B.C. Canada. Tailboom separated at tailboom centre support fitting (rivet head fretting).

AIRCRAFT TYPE (ROTARY-WING)

Flight Controls

M19 Hughes 269B 5 Feb 77 2 D Cascade Creek, New Zealand.
Upper scissors link support of main rotor.
Possible installation of wrong thrust bearing.
Airframe hours: 6616.

Engine/Transmission

N10 Hughes 269A 21 Apr 65 0 D Columbus, Ohio USA.
Engine flywheel weight assembly.

N12 Hughes 269B 25 Feb 66 0 S May Pen, Jamaica.
Fuel feed pipe-line to No. 3 cylinder.

N20 Hughes 269B 4 Feb 67 0 S Culver City, Cal. USA.
Attach fitting of clutch actuator electro-mechanical unit. No lubrication on pin or fitting.

N21 Hughes 269B 13 May 67 0 S Saluda, S.C. USA.
Malfunction of main rotor gear drive assembly due to failure of huck bolts, P/N SALP-T10-7.

N22 Hughes 269B 30 May 67 0 S Lakewood, Cal. USA.
Improper con rod bolts, P/N 75060, in no. 4 cylinder failed.

N23 Hughes 269A 12 Oct 67 0 S Lula, Miss. USA.
Lower coupling drive shaft, P/N 269A5504

N31 Hughes 269B 17 Aug 69 0 D Lakewood, Calif. USA.
Failure of electro-mechanical actuator in transmission rotor drive system created disconnect of power drive pulley belts to engine.

N32 Hughes 269B 17 Mar 70 0 S Santa Monica, Cal. USA.
No. 4 cylinder connecting rod.

N39 Hughes 269C 3 Dec 71 0 S Hallandale, Fla. USA.
1 exhaust valve.

N48 Hughes 269C 19 Oct 72 0 S Chamblee, Ga. USA.
#4 connecting rod bolt. Origin: surface damage.

N55 Hughes 269C 2 Oct 73 2 D Oakland, Calif. USA.
Main-rotor gear drive-shaft failed, main rotor separated.

N56 Hughes 269B 16 Oct 73 2 D Springfield, Ohio USA.
Lower-coupling drive shaft failed, tail-rotor drive-shaft assembly. Tail rotor separated.

N66 Hughes 269B 19 Mar 75 0 S Gail, Tex. USA.
No. 4 conrod.

N77 Hughes 269C 2 Aug 76 0 D Miyagi Pref., Japan.
Stress concentration, exhaust valve of #2 cyl.

N90	Hughes 269C	22 Aug 77	0	D	Yamagata Pref., Japan. Pitting corrosion at 3rd stage compressor blade
N93	Hughes 269B	1 Dec 77	0	S	Speedway, Ind. USA. Main rotor gear box ring gear drive coupling P/N 269A5180.
N112	Hughes 269	1980	0	S	Grove Hill, Australia. Lower pulley coupling shaft in transmission rotor drive system.
N115	Hughes 269C	4 Apr 80	0	D	Te Angra, Te Kuiti, New Zealand. Main rotor ring gear drive shaft, P/N 269A 5179M. Origin: fretting near lockpin holes. Total time: 3316 hours.
N120	Hughes 269B	12 Jul 80	0	S	Washington, D.C. USA. Fatigue fracture of #5 hold down stud on #3 cylinder. Corrosion.
N123	Hughes 269C	31 Oct 80	0	D	170 nm north of Osteraund, Sweden. Transmission drive shaft, P/N 269A5559, broke 9 cm from end. Torsional fatigue. Subsurface initiation.
N125	Hughes 269C	10 Jan 81	0	D	Viper, Ky. USA. Lower coupling drive shaft, PN 269A5504.
N133	Hughes 269C	4 May 81	0	S	Washington, D.C. USA. Main rotor shaft ring gear carrier, P/N 269A5179-3, cracks in outer race support radius
<u>Landing Gear</u>					
05	Hughes 269A	31 Jul 74	0	D	W. Memphis, Ark. USA. Landing gear strut assembly.
09	Hughes 269C	1978	0	S	Surfers Paradise, Australia. Cracks in both skid gear & left forward shock strut.
<u>Miscellaneous</u>					
P26	Hughes 269C	26 Jul 75	0	S	Ensch, W. Germany. Bearing cage of main rotor clutch.

HUGHES 369/500/OH-6A CAYUSE

<u>Tail Rotor</u>					
K49	Hughes 369HS	20 Feb 75	0	S	Grand Chenier, La. USA. Tail rotor blade P/N 369A1613-3.
K71	Hughes 369H	25 Jul 77	0	D	Hiroshima Pref. Japan. Tail rotor hub failed (maraging steel). Origin: pitting corrosion.
K81	Hughes 369D	14 Aug 78	0	D	Cascadia, Oregon USA. Tail rotor hinge bearings worn. Vibration allowed tail rotor hub to fail. Role: logging.

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AIRCRAFT TYPE (ROTARY-WING)

	<u>Engine/Transmission</u>				
N42	Hughes OH-6A Cayuse (US Army)	15 May 72	0 D?	Vn. USA. Engine failure (band & vane assembly).	
N47	Hughes OH-6A Cayuse (US Army)	17 Sep 72	0 S	Vn. USA. Engine failure (compressor rotor).	
N52	Hughes 369HS	28 Mar 73	0 S	Point La Hache, La. USA. Compressor, spur adapter gear shaft.	
N57	Hughes 369H	1974	0 D	Derby, W.A., Australia. Out-of-balance blade due to loss of abrasion tape caused gearbox separation (fatigue) at flange.	
N60	Hughes 369HS	2 Apr 74	0 S	Petersburg, Alas. USA. 1st stage turbine wheel (thermal fatigue).	
N73	Hughes 500	12 Jan 76	0 S	Mildred Lake, Alta. Canada. Compressor. Allison 250 engine.	
N74	Hughes 369HS	26 Jan 76	0 S	Yokohama, Japan. 3rd stage compressor blade. Origin: pitting corrosion.	
N78	Hughes 369HS	5 Sep 76	0 S	Hornu, Belgium. 4th stage compressor blade.	
N121	Hughes 500	25 Jul 80	0 S	Falcon Lake, Man. Canada. Tooth on output drive bevel gear in main rotor drive assembly. Coarse machining marks in root fillet of teeth.	
N136	Hughes 500	24 Aug 81	1 D	Philomena, Alta. Canada. Transmission input pinion (corrosion pit). 2400 hour service life limit possibly exceeded.	
	<u>Miscellaneous</u>				
P37	Hughes 500	8 Oct 79	0 S	Jenpeg, Man. Canada. Tail rotor drive flexible coupling.	
P38	Hughes 369D	18 Oct 79	0 D	Trenton, N.J. USA. Tail rotor drive shaft coupling failed, causing tail rotor separation.	
P41	Hughes 369HS	26 Jun 80	0 S	Herbert, New Zealand. Tail rotor transmission housing. Total time: 2220 hours. ASTM B80 magnesium casting alloy AZ91C. Origin: microporosity.	

KAMAN HH-43

	<u>Engine</u>			
N110	Kaman HH-43F	24 Aug 79	0 D	Hamilton, Mt. USA. Fracture of engine drive shaft (powershaft) P/N 1-100-620-01 in area of heavy wear.

KAWASAKI KH-4 (See Bell 47)

KAWASAKI KV-107 (see Boeing Vertol Model 107)

MBB BO 105

Engine

N84 MBB BO 105 7 Jun 77 0 S Intracoastal City, La. USA.
Right engine fourth stage turbine wheel
shattered. Corroded and fatigue fracture.
3425 hours & 5313 cycles on wheel.

Tail Rotor System

M23 MBB BO 105 15 Dec 77 0 D Kassel, W. Germany.
Tail-rotor pitch control linkage, rotor control
shaft fitting. Tail rotor separated

ROBINSON R22

Main Rotor

J55 Robinson R22 Fall 81 ? ? Ellington, Conn. USA.
Failure of Al61 rotor fitting. Airframe hrs:
691. Ref: Rotor & Wing Intl., Jan. 82 p 62

Miscellaneous

P43 Robinson R22 6 Aug 81 0 S Cincinnati, Oh. USA.
Support bracket for tail rotor drive shaft
damper, PN A041-1.

ROTORWAY SCORPION TOO

Tail Rotor

K84 Rotorway 27 Mar 79 1 S Johns Island, S. Carolina, USA.
Scorpion Too Tail rotor blades separated.

S.N.I.A.S. (See Aerospatiale)

SIKORSKY S-51

Main Rotor

J5 Sikorsky 27 Aug 51 1 ? Lynwood, Calif. USA.
S-51 Fatigue failure of flapping hinge of main rotor
hub caused separation of blade.

Tail Rotor System

P8 Sikorsky 29 Aug 67 0 S Windsor Locks, Conn. USA.
S-51 Tail rotor drive shaft assembly (drive shaft
rivets sheared).

SIKORSKY S-52

Tail Cone Pylon

L5 Sikorsky 28 Jun 67 0 S Kingston, Jamaica.
S-52-3 Tail rotor separated. Tail cone pylon tube
separated at station 72.

SIKORSKY/WESTLAND S-55 (H-19)

Fuselage

L2 Sikorsky 15 Oct 65 0 S Fogo Village, Nfld. Canada.
S-55 Tail rotor pylon lower attachment ring.
(Magnesium alloy casting).

AIRCRAFT TYPE (ROTARY-WING)

L8 ⁵⁰	Sikorsky S-55	23 Jul 68	0	D	Marathon, Ont. Canada. Bolts attaching the tail rotor pylon assembly (threads).
L13	Sikorsky S-55	19 Sep 73	0	S	Duette, Fla. USA. Tail boom pylon ring P/N S14-20-3013.
L30	Sikorsky S-55	15 Aug 78	0	S	Carver, Ma. USA. Attach bolts of vertical pylon of tail boom.
L31	Sikorsky S-55	6 Nov 78	0	S	Quesnel, B.C. Canada. Tail rotor pylon assembly. Fretting fatigue pre-cracking of assembly in area of tail cone ring. 3860 airframe hours.
<u>Flight Controls</u>					
M6	Sikorsky H-19G	1 Oct 68	0	S	Mandeville, La. USA. Tail rotor control rod bearing broke, allowing blades to cone.
<u>Engine/Transmission</u>					
N6	Sikorsky S-55	4 Aug 64	0	S	Esker, Lab. Canada. No. 8 cylinder exhaust valve housing at rocker shaft small bushing boss.
N14	Sikorsky S-55	22 Jun 66	0	S	Prince George, B.C. Canada. No. 1 cylinder exhaust rocker box casting.
N51	Westland Whirlwind S-55	28 Feb 73	4	D	Eket, Nigeria. Failure in transmission/rotor drive main gearbox.
<u>Miscellaneous</u>					
P9	Westland Whirlwind HC.12 (Queen's Flight, RAF)	7 Dec 67	4	D	England. Main rotor shaft. Crack at rotor head end of drive shaft, inside the main-rotor gearbox.
P17	Sikorsky S-55B	18 Jul 72	0	D	Benicia, Calif. USA. Front transmission support bracket failed. Over-sized engine installed.
P39	Sikorsky S-55	23 Oct 79	1	D	Davenport, Florida, USA. Main transmission support assembly separated.
<u>SIKORSKY S-58/WESTLAND WESSEX</u>					
<u>Main Rotor</u>					
J7	Sikorsky S-58C	27 Jul 60	13	D	Forest Park, Ill. USA. Main rotor blade. Origin: lower external back-wall radius of spar.
J44	Sikorsky S-58ET	1 Oct 78	1	D	Steamboat Springs, Colo. USA. Horiz hinge pin failed, main rotor blade.
<u>Tail Rotor</u>					
K85	Sikorsky S-58ET	16 Mar 79	0	D	Nova Vicosa, Brazil. Tail rotor blade.

<u>Airframe</u>				
L11	Sikorsky S-58ET	25 Mar 72	0	S Darwin, Australia. Tail rotor assembly and gear box separated. Cracks in gear box mounting flange. Pylon fitting also had cracks.
<u>Engine</u>				
N3	Sikorsky S-58D	11 Jul 63	0	S Larchwood, Ont. Canada. Threaded end of knuckle pin retaining bolt.
N88	Westland Wessex 31B (RAN)	13 Jul 77	0	D At sea, HMAS Melbourne. Engine compressor blades.
N91	Sikorsky S-58	30 Sep 77	1	S Garmisch-Partenk, W. Germany. Carburetor: mixture-control pressure-diaphragm.
N96	Westland Wessex 31B (RAN)	22 Jan 78	0	S At sea, off Nowra, Australia. Drive shaft of engine-driven fuel pump.

SIKORSKY S-61 (SH-3 SEA KING)

<u>Main Rotor</u>				
J16	Sikorsky S-61L	14 Aug 68	21	D Compton Calif. USA. Failure of shank of yellow main rotor blade spindle, causing separation of blade.
J29	Sikorsky S-61N	10 May 74	6	D North Sea, 110 nm n. of Texel, Netherlands. Separation of no. 3 main-rotor blade. Origin: corrosion at bottom of spar, near back wall at pocket # 12. Airframe hours: 3830.
J40	Sikorsky S-61R (US Coast Guard)	May 78	? ?	USA. Main rotor blade separated at 1850 hrs. Origin: fault in plating of spindle lug bore.
J41	Sikorsky S-61N	26 Jun 78	18	D North Sea, off Norway. Lost a main rotor blade. Failure of rear lug on no. 5 main rotor blade spindle.

<u>Tail Rotor System</u>				
K86	Sikorsky S-61L	18 Apr 79	3	D Newark, N.J. USA. 35 in. of black tail rotor blade separated. P/N S6115-30001-044. Origin: outboard corner of aft face of leading-edge spar. 2444 hours on blade.
K99	Westland Sea King HAS Mk.1 (Belgian AF)	28 Apr 81	0	S Oostende, Belgium. Lug of tail rotor blade fitting.

<u>Engine/Transmission</u>				
N70	Sikorsky Sea King 50 (RAN)	21 Oct 75	0	D At sea off Nowra, Australia. Transmission oil filter retaining bolt.
N80	Sikorsky Sea King 50 (RAN)	2 Dec 76	0	D At sea off Nowra, Australia. Transmission oil filter retaining bolt.

AIRCRAFT TYPE (ROTARY-WING)

N129 Sikorsky 15 Apr 81 0 D Cape Town, South Africa.
S-61L
Mark I
Spur gear P/N S6135-20608-1 in main rotor gear-box. Cracks initiated at several positions on hub, and radiated outwards. (Excessive wear on camshaft lobes in roller contact area).

Landing Gear

01 Sikorsky 15 Jul 63 0 S Los Angeles, Ca. USA.
S-61
Right main gear failed. Forged fittings P/N S6125-50312-2 and S6125-50313-1. Origin: sharp corner on inside surface of closed end of tubular section.

02 Sikorsky 15 Mar 66 0 S Los Angeles, Cal. USA.
S-61L
Right landing gear brace fitting.

08 Sikorsky 16 May 77 5 S Pan Am building, New York, USA.
S-61L
Upper-right forward fitting of right main landing gear tube assembly. Material: 7075-T73.

Tail Rotor Drive Shaft

P36 Sikorsky 23 May 79 0 D At sea off HMAS Melbourne.
Sea King 50
(RAN)
Tail rotor drive shaft.

SIKORSKY S-62

Tail Rotor System

P27 Sikorsky 3 Oct 75 0 D 30 km from Reykjavik, Iceland.
S-62A
Driving gear of intermediate gear box failed (fatigue), causing tail rotor failure. A slipping bearing race contributed.

SIKORSKY S-64 SKYCRANE (CH-54)

Main Rotor

J49 Sikorsky 29 Sep 79 4 D Oh. USA.
CH-54A Tarhe
((US Army)
Main rotor separated (horizontal pin).

Flight Controls

M11 Sikorsky 2 Sep 69 3 D Prudhoe Bay, Alaska USA.
S-64E
Tail-rotor pitch-control link assembly failed, causing tail rotor to separate.

Engine

N135 Sikorsky S-64 5 Jun 81 1 S Kitsault River, B.C. Canada.
Skycrane
No. 1 engine, 6th stage compressor disc.

SIKORSKY S-65A (HH-53/CH-53 SEA STALLION)

Main Rotor

J18 Sikorsky late 1960s ? ? ?
CH/HH-53 to 1980
Spar of main rotor blade.

J19 Sikorsky late 1960s ? ? ?
CH/HH-53 to 1980
Spar of main rotor blade.

J30 Sikorsky 8 Jan 75 4 ? Salisbury, Md. USA.
CH-53D
Sea Stallion
(US Marines)
Main rotor blade.

SIKORSKY S-76 SPIRIT

- | | | | | |
|-------------------|----------------|-----------|----|--|
| <u>Main Rotor</u> | | | | |
| J42 | Sikorsky S-76A | 28 Jul 78 | 0 | S W. Palm Beach, Fla. USA.
Main rotor failure, quill shaft. P/N X7606-46420-041. |
| J51 | Sikorsky S-76A | 20 Mar 80 | 14 | D Off the Brazil coast.
Inboard spindle bearing became displaced, causing fracture of main rotor head spindle (1st thread at spline inboard end). Total time on spindle: 650 hours. |
| J53 | Sikorsky S-76A | 13 Mar 81 | 4 | D North Sea, Aberdeen, Scotland.
Excessive wear on Teflon-impregnated outer bearing caused main rotor spindle to crack at inboard end. Time on spindle: 1250 hrs? |

Flight Controls

- | | | | | |
|-----|---------------|-----------|----|--|
| M37 | Sikorsky S-76 | 30 Apr 82 | 13 | D Krahisland, Thailand.
Left tail rotor control cable fractured (improper rigging). |
|-----|---------------|-----------|----|--|

SOLOY 47 (See Bell 47)

SUD AVIATION (See Aerospatiale)

TOM CAT I

- | | | | | |
|-------------------|-----------|----------|---|--|
| <u>Tail Rotor</u> | | | | |
| K93 | Tom Cat I | 1 May 80 | 0 | D Watsonville, Ca. USA.
Tail rotor blade. Blade was 632 hours beyond required removal time. 1232 hours on blade. Role: crop spraying. P/N 47-642-102. |

VERTOL MODEL 42/H-21 WORK HORSE

- | | | | | |
|-------------------|-----------------------------|-----------|---|---|
| <u>Main Rotor</u> | | | | |
| J9 | Vertol 42A H-21B Work Horse | 17 Oct 63 | 0 | S Brass Radio Station, Que. Canada.
Rear green main rotor blade at tubular spar 3 feet outboard of rotor head. (Corrosion pits). |

VERTOL MODEL 44

- | | | | | |
|-------------------|------------|-----------|---|--|
| <u>Main Rotor</u> | | | | |
| J6 | Vertol 44B | 12 May 59 | 0 | S New York, N.Y. USA.
Tuning weight strap in forward rotor blade. |

VERTOL MODEL 107 (See Boeing Vertol Model 107)

WESTLAND WESSEX (See Sikorsky S-58)

WESTLAND WHIRLWIND (See Sikorsky S-55)

WESTLAND SEA KING (See Sikorsky S-61)

TYPE UNKNOWN (AUTOGYRO)

- | | | | | |
|-------------------|-----------------|------|---|--|
| <u>Main Rotor</u> | | | | |
| J1 | autogyro (USAF) | 1937 | 0 | D USA.
Main rotor blade at outboard pin hole of hub attachment. |

AD-A137 255

A SURVEY OF SERIOUS AIRCRAFT ACCIDENTS INVOLVING
FATIGUE FRACTUREVOLUME 2. (U) NATIONAL AERONAUTICAL
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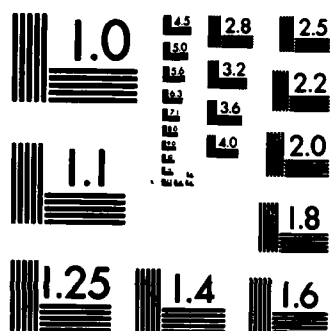
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Q-32

AIRCRAFT TYPE (ROTARY-WING)

TYPE UNKNOWN (HELICOPTER)

J2 Main Rotor
Type unknown 1940-51 1? ? USA.
(US helicopter) Main rotor link at lower lug. Origin: inside of
hole at point where bushing ended.

TYPE UNKNOWN (HELICOPTER)

J3 Main Rotor
Type unknown 3 Apr 46 ? D USA?
(helicopter) Certified helicopter with less than 100 hours
total time crashed. Failure of rotor hub.

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SUMMARY/SOMMAIRE This is Volume 2 of a world-wide survey of serious aircraft accidents involving fatigue fracture. Volume 2 of the report deals with rotary-wing aircraft, while Volume 1 addressed fixed-wing aircraft. A total of 419 rotary-wing accidents since 1937 were identified as having fatigue fracture as a related cause, and these accidents resulted in 379 fatalities. The accidents cover civil and, to a limited extent, military aircraft. Accidents are listed by failure type, as well as by aircraft type. Engine/transmission failure and tail-rotor failure were the most common cause of rotary-wing accidents, and currently there is an average of about 31 rotary-wing fatigue accidents per year. 15				

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